THE PRINCIPLES

OF

HYGIENE

A Practical Manual for Students, Physicians, and Health-Officers

BY

D. H. BERGEY, A. M., M. D., Dr. P. H.

Assistant Professor of Hygiene and Bacteriology, University of Pennsylvania

SEVENTH EDITION, THOROUGHLY REVISED

PHILADELPHIA AND LONDON

W. B. SAUNDERS COMPANY

1921

PRINTED IN AMERICA

PRESS OF
W. B. SAUNDERS COMPANY
PHILADELPHIA

PREFACE TO THE SEVENTH EDITION.

The extension of knowledge in the entire domain of hygiene, especially through the influence of various war activities upon health, has necessitated the revision of the text in many particulars.

The application of preventive measures on the extensive scale demanded by the war has emphasized the importance of numerous public health measures. On the other hand, the continued prevalence and lack of definite prophylactic agents for such diseases as scarlet fever, measles, mumps, and pneumonia, and especially for influenza and poliomyelitis, demand renewed efforts to discover prophylactic agents that will bring these epidemic diseases under control.

The operations of the enemy in using poisonous gases has been met, in part, by the perfection of absorbent and neutralizing materials that may be used in "gas masks" to protect against the detrimental effects of the gases employed. Some additional protection is needed, however, against gases of the type of "mustard gas," so as to protect all the body surfaces. It is difficult to keep pace with the ingenuity of a resourceful foe in order to solve these problems of health protection.

Many sections of the book have been rewritten, at least in part, and the subject matter brought up to date as far as possible.

D. H. B.

January, 1921.

PREFACE.

THIS book has been prepared to meet the needs of students of medicine in the acquirement of a knowledge of those principles on which modern hygienic practices are based; to aid students in architecture in comprehending the sanitary requirements in ventilation, heating, water-supply, and sewage-disposal; and to aid physicians and health officers in familiarizing themselves with the advances made in hygienic practices in recent years.

The rapid strides made in our knowledge of the entire subject of hygiene has rendered such a book, based upon the more recent discoveries, almost a necessity to students of medicine.

No attempt has been made to treat the subject in an exhaustive manner, the object being merely to give the general principles upon which the health officer and the physician work in their respective capacities in dealing with conditions which are detrimental to health or which tend to improve health.

The entire range of subjects comprising the comprehensive field of hygiene has not been discussed, but all those subjects which appeared to the author to be most important for those for whom the book has been prepared have received the consideration which their relative importance demanded.

The metric system of weights and measures has been employed throughout the work except in quotations,

because this system is now in general use in all scientific laboratories in the United States, and because it is in every way preferable to the cumbersome and complicated system, with its various units, which is still in common use. The metric system was employed also because it is in common use on the Continent of Europe, and is also a legal system in the United States since 1866, when Congress passed an act making its use lawful in the construction of contracts and in all legal proceedings. It is rapidly coming into general use in medicine and pharmacy, and its general adoption has the hearty endorsement of numerous scientific societies. At the present time a bill is passing through Congress which, when enacted, will make its employment compulsory in all departments of the Government after January 1, 1903.

In the Appendix the relative values of the units of weights and measures of the metric system have been given in terms of the English system, and *vice versa*.

D. H. B.

CONTENTS.

CHAPTER XX.

THE PRINCIPLES OF HYGIENE.

INTRODUCTION.

THE comprehensive nature of the subject precludes the possibility of giving a short and precise definition. A late writer on hygiene has given the following definition: "Hygiene aims to make growth more perfect, life more vigorous, decay less rapid, death more remote." Hence hygiene treats of the laws of health; of all those measures which tend to preserve the body in a healthy condition, as well as those which tend to improve the general health. It embraces a knowledge of the factors and conditions which bring about ill health and disease, as well as a knowledge of the methods of preventing disease, and of the measures which tend to fortify and improve the organism.

Health is that condition of the body in which all the various functions are performed normally, and without the manifestation of discomfort in any of its operations. **Disease,** on the other hand, implies the imperfect performance of one or more of the bodily functions because of the impaired structure of the corresponding organ or organs, and the consequent manifestation of discomfort, either in the part directly affected or in the body generally.

There are many factors which may operate in such a manner as to bring about disease. These factors are usually divided into the immediate and remote causes of disease.

The **immediate causes** of disease may be again divided into three classes, physical, chemical, and vital. The *physical* causes of disease are such as are brought about by physical agencies. The diseases which are due to

physical agencies are burns, cuts, bruises, fractures, and the like, and those diseases of the respiratory organs due to the inhalation of various forms of dust. The *chemical* causes of disease are corrosive and irritating drugs and chemicals which act directly through their corrosive action upon the part with which they are brought in contact, or indirectly through action upon the system after having been absorbed into the circulation. The *vital* causes of disease are the most important, because they are the most numerous and are frequently communicated from the sick to the well. They are also of great hygienic importance, because most of them are preventable. The vital causes of disease which are known to-day are the animal and vegetable parasites that are capable of lodging upon the surface of the body or penetrating into the blood and tissues, and thus give rise to disordered function either by producing obstruction, local irritation, absorbing large quantities of nourishment from the body, or by generating highly poisonous secretion and excretion products which produce disease through their local or general action. The principal animal parasites which produce disease are the various forms of intestinal worms, the trichinella spiralis, the filariæ, the itch mite, the trypanosomata, and the malarial organisms. The principal vegetable parasites which produce disease are the different forms of pathogenic bacteria and the plants of somewhat higher order which produce tinea favosa and other skin diseases.

The **remote causes** of disease operate in such a manner as gradually to reduce the physical powers of the body, so as to make it possible for the vital causes to operate. The remote causes of disease may be such factors as undue exposure to extremes of heat and cold, dampness or undue dryness of the atmosphere, undue exposure to bright lights or strong currents of air may operate in this manner, prolonged absence of sunlight, deficient ventilation, the use of excessive amounts of certain kinds of food and drink, the continued use of a diet which is deficient in one or more of the elements which enter into the composition of the body, maintain-

ing the body in abnormal positions for a long time, undue physical or mental exertion, deprivation of food and sleep, and wearing of apparel which constricts certain portions of the body.

The causes of disease may also be divided into the predisposing and the exciting causes. The **predisposing causes** of disease are the various conditions which, by their influence upon the body, render it less resistant to the invasion of pathogenic bacteria, or otherwise predispose to disordered health. The conditions which have been classed as remote causes of disease also belong in this class, but besides these there are other important conditions which predispose to disease, such as the age and sex of a person, hereditary influences, race, conjugal condition, the hygienic condition of the environment, the density of the population, the nature of the occupation, and the climate of the locality. Dr. Farr found that the mortality increases with the density of the population, not in direct proportion to the density, but as its sixth root.

The **exciting causes** of disease are the specific elements which are the etiologic factors in the production of disease. These are synonymous with the immediate causes of disease in the first classification, the physical, chemical, and vital causes of disease.

Predisposing Causes of Disease.—1. *Age.*—The influence of age is a most important factor in the production of disease. The age groups in which the mortality is greatest are to be found in the periods of growth and decline, while the mortality is lowest during youth and the earlier periods of adult maturity. The highest mortality occurs among children under one year of age, and then decreases rapidly until we reach the fifteenth year, after which it again gradually increases until we reach the period between sixty and seventy years, when it again decreases. The following table, taken from the annual reports of the Bureau of Health of the city of Philadelphia, shows "the percentage of deaths to total

mortality during specified periods of life," for the years 1914 to 1918.

THE PERCENTAGE OF DEATHS AND TOTAL MORTALITY AT DIFFERENT PERIODS OF LIFE IN PHILADELPHIA FOR THE YEARS 1914 TO 1918, INCLUSIVE.

Years.	1914.		1915.		1916.		1917.		1918.	
	Deaths.	Per Cent.	Deaths.	Per Cent.	Deaths.	Per Cent.	Deaths.	Per Cent.	Deaths.	Per Cent.
0– 1	4,981	14.78	4,218	16.04	4,153	15.03	4,617	15.92	5,366	12.58
1– 2	1,021	3.79	937	3.56	1,016	3.68	1,031	3.47	1,760	4.13
2– 5	935	3.47	722	2.74	944	3.41	918	3.09	1,639	3.84
5– 10	540	2.04	487	1.85	562	2.03	623	2.10	1,253	2.93
10– 15	300	1.11	312	1.18	347	1.25	368	1.24	722	1.79
15– 20	500	1.85	556	2.11	529	1.90	574	1.93	1,448	3.39
20– 30	1,806	6.70	1,813	6.89	1,935	7.00	2,180	7.28	6,622	15.52
30– 40	2,301	8.54	2,343	8.91	2,563	9.26	2,757	9.30	6,105	14.32
40– 50	2,971	11.03	2,895	11.01	3,171	11.48	3,541	11.94	4,349	10.19
50– 60	3,339	12.40	3,430	13.04	3,705	13.41	4,040	13.63	4,142	9.71
60– 70	3,603	13.84	3,735	14.20	3,950	14.30	4,095	13.81	4,242	9.94
70– 80	3,076	11.42	3,208	12.20	3,233	11.70	3,315	11.18	3,323	7.86
80– 90	1,335	4.95	1,420	5.40	1,303	4.71	1,426	4.81	1,474	3.47
90–100	200	0.74	199	0.75	198	0.71	189	0.63	196	0.47
100–110	10	0.03	11	0.04	10	0.03	6	0.02	4	0.01
110–120	....	..	1	..	2	..	1	..	....	..
Total..	26,918		26,287		27,621		29,681		42,643	

The very high morbidity and mortality from influenza in 1918 in persons between twenty and forty years of age is shown in the percentage of deaths in these ages as compared with the records for previous years as shown in tables.

A comparison of the number of deaths and percentage of deaths in persons over thirty years of age for the years 1889 to 1894 and 1909 to 1913 shows that they are both higher in the second period of five years than in the first period. These results are shown in a more striking manner in the following table:

YEAR.	1889–1894.	1909–1913.
	Per cent.	Per cent.
0– 1	24.26	18.27
1– 2	6.18	4.17
2– 5	6.64	3.99
5– 10	3.69	2.18
10– 15	1.42	1.24
15– 20	2.62	2.38
20– 30	8.91	6.65
30– 40	8.93	9.59
40– 50	8.19	10.58
50– 60	8.09	11.81
60– 70	8.84	12.70
70– 80	7.66	10.65
80– 90	3.89	4.75
90–100	0.61	0.66
100–110	0.03	0.03
Total	99.86	99.22

The high infantile mortality is due, primarily, to the effects of faulty nutrition, owing to the fact that so many infants must be fed with artificial foods. The secondary causes of the high infant mortality are the acute catarrhal inflammations of the gastro-intestinal and respiratory tracts. The following table shows the relative frequency of the diseases of the type of acute catarrhal inflammations of the gastro-intestinal and respiratory tracts as compared with the death-rate from the acute infectious diseases, of diseases of the nervous system, and the deaths from all causes in children under one year of age, in Philadelphia during the years 1914 to 1918, inclusive:

DURING THE YEARS 1914 TO 1918, INCLUSIVE.

Deaths under one year from—	1914.	1915.	1916.	1917.	1918.
All causes	4981	4218	4153	4617	5366
Diseases of gastro-intestinal tract	1612	1289	1269	1327	1309
Diseases of the respiratory tract	953	743	736	944	1284
Acute infectious diseases	208	118	187	224	185
Diseases of nervous system	81	113	137	88	83

The principal causes of death in persons over sixty years of age are shown in the following table, as indicated by the annual reports of the Bureau of Health of Philadelphia for the years 1914 to 1918, inclusive. The table also shows the total number of deaths for the same years, and the deaths from all causes for persons over sixty years of age.

DEATHS FROM CERTAIN CAUSES IN PERSONS OVER SIXTY YEARS OF AGE.

	1914.	1915.	1916.	1917.	1918.
Total deaths, all ages	26,918	26,287	27,621	29,681	42,643
All causes, over sixty years	8,224	8,574	8,696	9,032	9,247
Old age	234	206	184	129	130
Disease of the heart	1,778	1,804	1,956	2,083	2,170
Inflammation of lungs	724	541	874	958	942
Apoplexy	714	704	582	602	633
Paralysis	100	75	84	60	66
Tuberculosis	226	252	243	247	302
Cancer	660	679	773	796	811
Bright's disease	1,225	1,239	1,365	1,446	1,414
Influenza	84	183	186	131	324
Inflammation of bronchi	187	166	159	162	183
Inflammation of stomach and bowels	95	81	67	97	86
Inflammation of kidneys	101	100	80	52	24

In the period of life now under discussion, the period of decline, diseases dependent upon degenerations of the tissues and organs are the most prevalent, especially diseases of the vascular system, and it is probable that the causes of those deaths described by the vague terms "old age" and "debility" are usually dependent upon degenerations of this character.

2. *Sex.*—The influence of sex as a predisposing cause of disease does not manifest itself to any extent until after puberty, and again becomes less marked after the age of forty-five to fifty years. Certain diseases are far more prevalent in women than in men, such as hysteria and allied nervous diseases; while epilepsy, locomotor ataxia, gout, and acute diseases of the respiratory tract are more prevalent in men than in women. Women have a greater average longevity than men, because they are exposed less and are not engaged in such dangerous occupations.

RELATIVE NUMBER OF DEATHS AMONG MALES AND FEMALES IN PHILADELPHIA, 1914 TO 1918.

	1914.		1915.		1916.		1917.		1918.	
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.
Epidemic diseases..	617	583	564	512	687	609	765	712	4918	4617
General diseases...	2990	2624	3011	2587	3302	2719	3495	2852	3472	3040
Diseases of nervous system.....	859	846	894	922	954	943	819	854	728	893
Diseases of circulatory system....	2159	2096	2186	2176	2252	2346	2439	2392	2420	2558
Diseases of respiratory system.....	2056	1838	2015	1871	2008	1808	2676	1970	5764	3846
Diseases of digestive system......	1731	1513	1514	1401	1606	1301	1706	1457	1654	1333
Diseases of genitourinary system...	1480	1408	1419	1405	1517	1515	1726	1552	1545	1531
Puerperal state....	....	313	....	282	....	289	....	259	....	255
Diseases of skin....	114	87	87	82	98	57	84	64	78	64
Diseases of locomotor system....	24	15	25	15	35	22	23	22	28	9
Malformation.....	94	70	92	80	131	99	131	98	134	99
Early infancy......	895	692	777	621	740	524	784	595	906	661
Old age...........	79	155	63	143	67	120	34	95	45	86
Violence..........	1068	485	1099	422	1295	565	1509	543	1395	653
Self-defined causes..	13	14	13	9	7	5	7	8	15	9
Still births........	1144	785	1158	813	....	....	....	....	....	....

3. *Heredity.*—Hereditary influences are such as act from within the body, and are, therefore, non-preventable. The influence of heredity is shown in the greater prevalence of certain diseases in one family than another.

This difference is brought about by certain constitutional conditions which are transmitted from generation to generation, and consists in a lessened capability of resisting unfavorable influences upon the system. This condition was believed, until recently, to be actually a transmission of disease, as, for instance, in tuberculosis. Since the discovery of the specific micro-organisms of a number of diseases the theory of direct transmission has been discarded to a great extent. At the present time it is believed, however, that a predisposition to develop tuberculosis is transmitted, and that in these subjects the disease is far more readily developed than in those without such hereditary predisposition. In like manner the transmission of a predisposition to develop other constitutional diseases is recognized to-day, such as carcinoma, gout, rheumatism, diabetes, disease of the circulatory organs, disease of the nervous system, especially insanity and hysteria, and malformations.

When the hereditary influences show themselves in the same sex in the offspring as in the parent, they are said to be homeomorphous, and when they show themselves in the opposite sex they are said to be heteromorphous.

Hereditary influences are intensified by the intermarriage of near relations, because these influences may be present in both parents.

Connate Conditions.—Connate conditions are such as are born into a person, as temperament, idiosyncrasy, and diathesis. Temperament refers mainly to the external appearance of the person, and indicates tendencies in various directions. The principal temperaments are the sanguine, the lymphatic, the neurotic, and the melancholic temperament. Idiosyncrasy has reference to special liability to certain affections, as hay fever; or peculiar susceptibility to the influence of drugs, as ipecac, opium, quinin, etc., or to certain articles of diet, as shell-fish, berries, etc. Diathesis has reference to special tendencies or predisposition to particular diseases, as catarrhal affections; the gouty and rheumatic diathesis, etc.; and indicates a weakness in a particular part of the body.

The late Prof. J. G. Richardson[1] states that "persons of a sanguine temperament are believed to be especially liable to organic diseases of the heart, to aneurysms, and to the bursting of blood-vessels in various parts of the body, so that they should especially guard against articles of food and habits of life which promote the formation of an excess of blood in the system. Individuals of lymphatic temperament seem particularly prone to scrofulous affections, consumption, dropsy, and skin diseases; those of bilious temperament, to diseases of the liver, stomach, and intestines; and those of nervous temperament to palsy, St. Vitus's dance, epileptic fits, etc."

4. *Race.*—The influence of race as a predisposing cause of disease is quite marked for some races. The Jews, as shown in a special study of this race by Dr. John S. Billings, are more liable to diseases of the nervous system, especially diseases of the spinal cord, to diarrheal diseases, diphtheria, diseases of the circulatory organs, the urinary system, bones and joints, and diseases of the skin. They are less liable to tuberculosis than their neighbors.

Detailed studies of the vital statistics of Boston, New York and Brooklyn, Philadelphia, Baltimore, and Washington for the six years ending May 31, 1890, by Dr. Billings, have shown that the death-rate among children of Irish mothers is greater from consumption, pneumonia, inanition, debility, atrophy, heart disease and dropsy, and from typhoid fever, than among children of German mothers, while the death-rate among children ot German mothers is markedly greater from Bright's disease than that of children of Irish mothers. A large part of the excessive death-rate among children of Irish mothers is due to tubercular diseases, and to the effects of alcohol, which last include a considerable part of the diseases of the nervous system, of the digestive tract, and of the urinary organs among adults. Cancer, tumor, and suicides are more frequent among those of German parentage.

The higher death-rate among the colored race was

[1] *Long Life, and How to Reach It.*

found to be due mainly to the excessively high death-rate among children of that race. The death-rate from consumption, pneumonia, typhoid fever, diphtheria and croup, diarrheal diseases of infants, diseases of the nervous system, and heart disease and dropsy, was found to be much greater among the colored population than among whites. The negro race is less liable to yellow fever and to malaria than the white race.

TOTAL DEATHS REPORTED IN PHILADELPHIA AND RATES OF TUBERCULOSIS AND SYPHILIS FOR WHITE AND COLORED POPULATION, 1903 TO 1917.
(*Annual Report of the Bureau of Health, 1917, p. 55.*)

Year.	Population estimated as of July 1st.	Total deaths.	Rate per 1000 of population.	Tuberculosis of lungs.		Syphilis.	
				Deaths.	Rate per 100,000 of population.	Deaths.	Rate per 100,000 of population.
WHITE:							
1903	1,302,690	24,510	18.81	2760	211.87	30	2.30
1904	1,326,371	24,478	18.45	2771	208.92	68	5.13
1905	1,350,052	23,228	17.21	2526	187.10	49	3.63
1906	1,373,733	25,337	18.44	2804	204.12	87	6.33
1907	1,397,414	25,182	18.02	2776	198.65	78	5.58
1908	1,421,096	23,697	16.68	2638	185.63	66	4.64
1909	1,444,778	22,914	15.86	2485	172.00	69	4.78
1910	1,468,459	24,740	16.85	2548	173.52	84	5.72
1911	1,492,884	24,251	16.24	2642	176.97	96	6.43
1912	1,517,309	22,805	15.03	2416	159.23	102	6.72
1913	1,541,733	23,405	15.18	2278	147.76	108	7.01
1914	1,566,158	24,624	15.72	2289	146.15	100	6.39
1915	1,590,583	23,952	15.06	2318	145.73	101	6.35
1916	1,615,008	25,193	15.60	2456	152.07	130	8.05
1917	1,639,567	26,505	16.17	2509	153.03	198	12.08
COLORED:							
1903	70,724	1,437	20.32	293	414.29	3	4.24
1904	72,897	1,493	20.48	346	474.64	3	4.12
1905	75,070	1,579	21.03	312	415.61	14	18.65
1906	77,243	2,431	31.47	357	462.18	17	22.01
1907	79,416	2,294	28.89	381	479.75	19	23.92
1908	81,589	2,229	27.32	430	527.03	20	24.51
1909	83,762	2,115	25.25	378	451.28	22	25.26
1910	85,935	2,305	26.82	459	534.12	18	20.95
1911	87,364	2,025	23.18	416	476.17	26	29.76
1912	88,793	1,708	19.24	318	358.14	23	25.90
1913	90,223	2,207	24.46	414	458.86	21	23.28
1914	91,652	2,294	25.02	395	430.98	41	44.73
1915	93,081	2,335	25.09	436	468.41	44	47.27
1916	94,510	2,428	25.69	457	483.55	46	48.67
1917	95,947	3,176	33.10	510	531.54	74	77.13

5. *Conjugal Condition.*—The influence of conjugal conditions upon death-rates is manifest from the following studies made in Baltimore and Washington for the Eleventh Census:

Death-rates.

Conjugal condition.	Baltimore.				Washington.			
	White.		Colored.		White.		Colored.	
	Male.	Female.	Male.	Female.	Male.	Female.	Male.	Female.
Single	9.19	6.53	13.75	13.20	10.07	6.44	19.98	14.50
Married . . .	8.98	9.76	13.49	16.31	9.06	9.56	16.60	16.70
Widowed . . .	26.90	12.10	12.02	14.36	40.17	13.65	50.51	15.12

The lower death-rate among the married than among either single or widowed is probably due to the better home care these individuals have, and also to the fact that they lead more regular lives. The extremely high death-rate among widowed males is, no doubt, traceable to the influences exerted by the destruction of the home and the effects entailed by this loss. Of course, the age factor also exerts an important influence upon the death-rate among the widowed.

6. *Hygienic Conditions of Environment.*—The influence of overcrowding and general unhealthy surroundings, along with privation and want, are most important as predisposing causes of disease. It is somewhat difficult to obtain statistical evidence of the unfavorable influence upon health of the general hygienic conditions of the surroundings, yet the following table, based upon the special Census Report for Philadelphia in 1890, shows this effect fairly well, especially with regard to the death-rate from consumption. It will be seen that, in general, in those wards in which the number of persons to a dwelling and the number of families to a dwelling are greater than the average for the entire city the death-rate from consumption is also above the average, and that, in general, in those wards in which the number of persons to a dwelling and the number of families to a dwelling are below the average the death-rate from consumption is also below the average for the entire city.

Aside from the influence of overcrowding, there are other conditions of environment that may be classed as predisposing causes of disease. The most prominent of

Philadelphia, 1890. Census Report.

Ward.	Persons to Dwelling.	Persons to Acre.	Death-rate per 1000 pop.	Death-rate per 100,000 pop.	Number of families to dwelling.	Population.	Area.
			All causes.	Consumption.			Acres.
5	7.48	88.94	25.67	498.02	1.43	16,987	205
6	6.81	44.68	24.30	418.46	1.38	8,712	205
11	6.71	95.95	28.31	330.86	1.38	12,953	135
4	6.53	141.56	29.98	441.11	1.24	20,384	147
9	6.45	38.25	25.10	364.04	1.10	9,791	256
8	6.41	61.27	24.26	332.28	1.08	16,971	278
7	6.35	110.14	24.30	408.91	1.20	30,179	281
10	6.33	98.69	19.88	278.12	1.07	21,514	230
27	6.30	4.51	31.91	504.81	1.05	32,905	[1] 7,475
3	6.19	164.67	23.91	313.33	1.23	19,925	122
15	6.09	99.82	20.08	288.71	1.10	52,705	671
12	6.08	114.27	21.57	314.16	1.21	14,170	124
2	6.06	115.62	23.93	316.35	1.23	31,563	283
13	5.90	109.96	20.67	260.98	1.16	17,923	163
17	5.82	122.93	28.89	355.83	1.19	19,546	161
34	5.66	(Includ	ed in 24th	ward).	1.04		
14	5.61	136.43	21.47	320.62	1.11	20,737	152
16	5.60	94.93	28.04	311.21	1.21	17,087	180
29	5.56	87.20	20.19	293.26	1.06	54,759	896
20	5.55	94.84	20.77	303.14	1.14	44,480	469
30	5.55	92.21	22.12	349.35	1.09	30,614	332
19	5.46	126.53	23.73	310.44	1.11	55,545	447
24	5.41	14.07	17.95	269.24	1.05	66,277	6,224
22	5.40	3.68	17.77	241.27	1.03	45,329	12,738
21	5.35	6.44	19.45	242.86	1.05	26,900	4,563
26	5.32	13.18	19.48	238.37	1.05	62,138	4,788
25	5.25	14.41	24.29	271.55	1.06	35,945	2,641
33	5.23	12.23	13.07	143.47	1.06	33,171	2,844
31	5.17	72.31	21.46	284.92	1.03	32,974	456
18	5.16	71.83	24.42	304.57	1.09	29,164	416
1	5.15	15.34	22.08	275.54	1.05	53,882	3,526
28	5.15	14.62	15.56	185.73	1.05	46,390	3,542
23	5.06	1.30	18.50	219.39	1.02	35,294	27,339
32	5.04	118.77	14.61	192.32	1.03	30,050	518
City	5.60	13.32	21.54	297.87	1.10	1,046,964	82,807

these factors are the nature of the water-supply and the character of the drainage. The relation of these factors to the public health will be considered in detail in special chapters. Dampness of the soil of a locality is also an

[1] Hospital and Almshouse.

important factor, and its influence in relation to consumption has been carefully investigated by Dr. Bowditch, of Boston, and Dr. Buchanan, of London. Their investigations have shown that the death-rate from consumption is in proportion to the dampness of the soil. Dampness of soil is also an important predisposing factor in the production of many other diseases, such as malaria, rheumatism, and catarrhal affections.

The influence of the nature of the occupation, and of the climate of a locality, as predisposing factors of disease will be discussed in detail in special chapters on these subjects.

Sanitary science refers to the investigation of the causes of disease and the means of avoiding or destroying them. It is not a specific department or separate branch of science, but is implied, in part, in a number of sciences, as chemistry, biology, physics, pathology, statistics, etc.

The term *sanitary* means conducive to the preservation of, and the term *sanitory* conducive to the restoration of, health. The sanitary condition of a place has reference to the presence or absence of the specific causes of disease. There is no such thing as *bad* hygiene: A place is either in hygienic condition or it is in an unhealthful condition.

Hygiene aims to discover the causes of all diseases known, and the best means of removing those causes or rendering them inoperative. It takes for granted a knowledge of the normal functions of the human organism, and seeks to discover the reasons for perverted action of a part or the whole of the organism. It involves a thorough knowledge of the normal conditions of man's environment as well as the various factors which tend to render that environment abnormal. It demands a thorough knowledge of the chemical and physical character of man's food-supply and those changes to which it is liable that tend to injure his health and produce disease. It aims to keep persons in perfect health, to train men to be strong both mentally and physically. It also involves a knowledge of the physical and geological nature of the

surface of the earth, and the manner in which these conditions, in different localities, influence the healthfulness of human habitations. It comprises a knowledge of all the various human ocupations, and the manner in which these may be conducted so as to be free from danger to health or how to render them least objectionable.

Hygiene may be subdivided into several departments relating to the scope of its application, as public or general, military, naval, personal, municipal, school, and industrial hygiene. Public hygiene takes cognizance of factors which affect the general public, such as nuisances of different kinds: Foul odors, noxious gases or dust evolved in certain manufacturing processes, and loud noises. Nuisances are generally such conditions which aggravate existing disease rather than produce disease. Military, naval, personal, school, and industrial hygiene will be treated more or less generally in special chapters. Municipal hygiene has reference to those conditions which affect the general health of a community that fall directly under the control of municipal governments, such as the influence of impure water-supplies and imperfect drainage upon the general health; the influence of overcrowding in the habitations of the poor; the cleansing of city streets and the removal and satisfactory disposal of refuse matters; the regulation of, the isolation and care of those affected with infectious diseases, and the proper disposal of the dead.

Development of Hygiene.—Modern hygiene has been gradually evolved out of the observations and discoveries of many men prominent in philanthropic work, in medicine, and in science. Among the prominent observations and discoveries made during the eighteenth century which have been most instrumental in the development of hygiene may be mentioned the discovery of Sir George Baker with regard to the production of lead-poisoning by cider stored in leaden vessels; the observations of John Howard with regard to the baneful influence of foul air and overcrowding and unhealthfulness of the surroundings upon the health of the occupants of prisons,

poor-houses, and other habitations, and their relation to typhus fever; the demonstration by Captain James Cook, in his voyage around the world, that scurvy was a preventable disease which was due to the nature of the diet; and Sir Edward Jenner's discovery of inoculation as a preventative of small-pox. During the nineteenth century the movements and discoveries which stand out most prominently are the work of Dr. Thomas Southwood Smith and The Sanitary Committee in demonstrating the factors which are instrumental in influencing the health of towns, such as the accumulation of filth about premises, absence of sewers, and consequently the pollution of water-supplies, and the influence of insufficient air-supply and overcrowding upon the general health; the labors of Edwin Chadwick in organizing the first board of health in England; the work of Dr. William Farr, Registrar-General of England, in securing the registration of the *cause* of death in the health reports; the labors of Dr. E. A. Parkes in demonstrating the evil effects of defective drainage and the accumulation of filth upon the public health, and in securing the passage of various sanitary acts from 1848 to 1857; the work of Dr. John Simon, of London, and his able staff of medical inspectors with regard to the material causes of disease, and the legislation which was based upon these investigations; the studies of Dr. C. A. Louis, of Paris, upon typhoid, typhus, and relapsing fevers, and the differentiation between these, as well as similar studies made at the same time by Dr. William W. Gerhard, of Philadelphia; the studies of Dr. Henry I. Bowditch, of Boston, and those of Dr. George Buchanan, of London, upon the influence of dampness of the soil upon the prevalence of consumption; the studies of Louis Pasteur upon the causes of fermentation and the etiologic relation of micro-organisms to disease, as well as his discoveries with regard to the prevention and treatment of these diseases; the studies of Sir Joseph Lister with regard to the prevention of suppuration in wounds, which have been the starting-point of modern

antiseptic and aseptic surgery; the work of von Pettenkofer in introducing new methods of chemical research upon air, water, and food, and his studies upon the influence of soil-moisture upon the prevalence of typhoid fever and cholera; and the discoveries of Dr. Robert Koch of the specific micro-organisms of some of the infectious diseases, and in perfecting methods of bacteriologic investigation.

Since we have become acquainted with the direct causative factors of many of the contagious diseases, we have developed preventive measures that were impossible before the causes of disease were known. The discovery of the influence of different chemical and physical agents, in destroying the bacteria outside the body, has been of very great value in limiting the dissemination of disease. The discovery of immune serums, especially the antitoxins of diphtheria and tetanus, has been of great service in limiting the dissemination of disease when employed both as prophylactic and curative agents. The introduction of the methods of immunization with dead cultures of bacteria for the prevention and cure of bacterial diseases has been an important step forward, especially in the control of cholera, plague, and typhoid fever. The discovery of the influence of certain suctorial insects in the dissemination of disease, as the several species of mosquitoes in the dissemination of malarial fevers, yellow fever, of filariasis, and of dengue; the rôle played by the rat flea in the dissemination of plague, the tsetse fly in the dissemination of sleeping sickness, the body louse in the dissemination of typhus fever, and the tick in the dissemination of African "tick" fever, are some of the more important of this class of diseases that can now be controlled more intelligently since the mode of dissemination is known. The introduction of modern methods of water purification and sewage disposal are also important factors in limiting the dissemination of disease by means that were unknown a quarter of a century ago.

CHAPTER I.

AIR.

Nature and Composition of the Atmosphere.—Atmospheric air consists of a mechanical mixture of gases, the relative proportions of which are fairly constant in all parts of the world. It is colorless, odorless, transparent, and is, therefore, invisible and imperceptible when quiescent. It is only when it is itself in a state of motion, or when our bodies are in rapid motion, that we note its presence through the resistance which it manifests. It also possesses weight, and consequently exerts pressure. At the sea-level, when the temperature is 0° C., the normal pressure of the atmosphere is sufficient to support a column of mercury 760 millimeters in height, and amounts to 1033 grams on every square centimeter of surface. The pressure of the atmosphere decreases as we rise above the level of the sea, and increases as we descend below its level.

The several gases composing the atmosphere are not in chemical combination with each other, but exist as a more or less homogeneous mixture. The principal gases in the mixture are: Nitrogen in the proportion of 78.20 parts, by volume; oxygen, 20.76 parts; argon, 1 part; carbon dioxid, 0.04 part; a trace of ammonia; traces of nitrous and nitric acids; small amounts of ozone; varying proportions of aqueous vapor; and traces of several recently discovered constituents: neon, erythron, and krypton.

The *proportion of nitrogen* in natural air varies only within extremely narrow limits. It is an indifferent gas, and seems to serve principally as a diluent for the oxygen in the air. So far as known, the only biologic significance of nitrogen is its absorption by plants of the order *Leguminosæ* when growing in symbiosis with certain micro-organisms which find lodgment on the roots of

these plants, and where they cause the formation of the so-called root-tubercles. Indirectly nitrogen is also stored in the soil by certain soil bacteria and, in turn, vegetation obtains this nitrogen as food in the form of nitrates and ammonia. Argon, neon, erythron, and krypton are likewise inert gases so far as known at the present time.

The *proportion of oxygen* in the air varies within somewhat wider limits than that of nitrogen, but, under natural conditions, it is fairly constant, because any slight decrease in its proportion in circumscribed localities is readily corrected through the action of the principle of diffusion.

The *proportion of carbon dioxid* varies usually between 0.03 and 0.05 part per 100, but it is subject to still greater fluctuations at different points on the earth's surface, and at different seasons of the year. The fluctuations in the proportion of carbon dioxid are brought about by the active decomposition and putrefaction of organic matters through the agency of bacteria, and through the combustion of combustible materials in manufacturing centres. The overproduction of carbon dioxid at any point tends to become equalized through the operation of the principle of diffusion and the movements of the atmosphere. The proportion of carbon dioxid is, generally, greatest at the surface of the earth, and decreases as the elevation increases. It is least in winter and greatest in autumn; less during the day than at night; less on the seacoast than inland; and less on windy days than on calm days. It is decidedly diminished by rain, slightly so by snow, and slightly increased during foggy weather.

The relative proportions of oxygen and carbon dioxid are maintained through the combined action of the vegetable and animal world. The animal kingdom absorbs oxygen and gives off carbon dioxid in return as the result of tissue metabolism. On the other hand, those members of the vegetable kingdom which possess chlorophyl in their organism have the property of absorbing carbon dioxid from the air, assimilating the carbon and giving off the oxygen in return. This most

interesting cycle is an important factor in the maintenance of the relative proportions of these two gases in the air.

The *proportion of aqueous vapor* in air varies with the temperature—the average amount being about 1 per cent. The amount of moisture in the air may vary from less than 0.1 per cent. to as much as 4 per cent. The higher the temperature, the greater the amount of aqueous vapor that is taken up by air. The proportion which is most agreeable to the majority of persons, and therefore the most suitable for health, is about 50 per cent. of saturation at any given temperature.

Ozone—condensed or allotropic oxygen—is present in variable amounts in different places on the earth's surface. The average amount present is 1 milligram per 100 cubic meters of air; the maximum amount being about 3.5 milligrams. This gas is usually absent from the air of cities and the air which has passed through localities that are thickly populated. It is found in the atmosphere over fields covered with vegetation, over forests, and over the ocean. Ozone is an active oxidizing agent, and the air of cities is rich in oxidizable organic matter which absorbs it, consequently it is absent from the air of cities. Generally speaking, the healthiest parts of towns are those receiving the purer and fresher air, containing ozone, coming from cultivated fields, forests, or the ocean.

The amounts of ammonia, nitrous and nitric acids, found in ordinary atmospheric air are insufficient to have any biologic significance. They result principally from putrefaction and from various manufacturing industries.

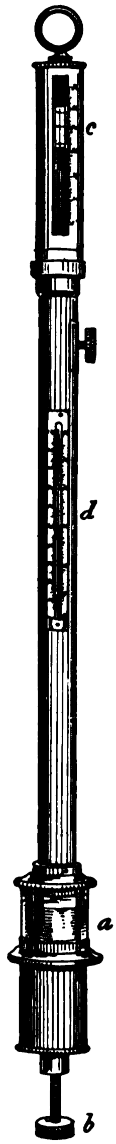
The atmosphere forms a gaseous envelope which surrounds the earth, reaching a height of from 320 to 350 kilometers above the earth's surface, and penetrating into the porous soil, into caves and mines, and into the ocean to a great depth.

Temperature of the Air.—There are three main factors that influence the temperature of the air of any place, viz., latitude, altitude, and the relative proximity of large bodies of water. The temperature is greatest

near the equator and decreases proportionately with the distance traversed in passing from the equator to the north or south pole. The temperature is also higher at the level of the sea than on the top of a mountain in the same latitude. Places near the seacoast also have a more equable climate than those in the interior. The other factors which influence the temperature of a locality are: The conformation of the earth's surface; the nature of the soil; the character and extent of the soil-covering; and the direction of the prevailing winds. Owing to the high specific heat of water (about five times that of earth and rocks) the ocean absorbs heat slowly and gives it off slowly, and, therefore, it acts as a reservoir of the heat, absorbing it during the day and giving it off during the night, also absorbing it during the summer and giving it off during the winter, thus lessening the heat of summer as well as the cold of winter for places along the seacoast.

Pressure of the Atmosphere.—The average pressure of the atmosphere varies according to the altitude of the locality, and also in the same locality at different times. At the sea-level this average pressure amounts to a little over a kilogram per square centimeter, and is sufficient to support a column of mercury 760 millimeters in height; hence the total weight supported by an average man is about 18,000 kilograms. This weight or pressure is considerable, but it is unnoticed because it is equalized by the internal pressure of our bodies, which adapt themselves to the normal fluctuations in the atmospheric pressure. Variations in the atmospheric pressure are measured by means of barometers. The mercurial barometer is usually employed in making these observations (Fig. 1). Marked deviations from the normal atmospheric pressure, such as are found in exceedingly high altitudes, in balloon ascensions to great heights, or when descending to great depths in mines, or working in tunnels, are manifested by effects which are referable to the increased or decreased tension of the atmosphere. Rarefied air as found at great heights induces a condition known as mountain sickness or balloon sickness, and consists in increased heart action,

more rapid respiration, headache, followed by graver symptoms as the rarefaction increases, such as vomiting of food, bile, and blood, with great pain in the stomach, followed by death. There are frequently minute hemorrhages into the spinal cord as the result of inspiring rarefied air. The insufficient supply of oxygen in the rarefied air is perhaps the principal cause of the symptoms manifested.



The effects of passing from the normal atmospheric pressure to a greater pressure, as in diving-bells, in tunnels under rivers, are different from those seen on ascending to a great height, and here the effects are due to the increased pressure upon the body. Every 10 meters of water adds the pressure of 1 atmosphere—1 kilogram per square centimeter of body surface. The increased pressure causes the sudden liberation of gases in the tissues and blood, where they interfere with the circulation and stop the heart. The difference in pressure on the tympanic cavity causes vertigo and pain in the ear, and if the difference in pressure is great the drum of the ear may be ruptured when the Eustachian tube is occluded. Ordinarily the difference in pressure is equalized by the act of swallowing. On coming out of a caisson the reverse in internal and external pressure takes place. This is also relieved in the same manner. Man can work at a kilometer below the sea-level without injury, and he can travel to a height of 5 or 6 kilometers without being affected by

FIG. 1.—Mercurial barometer: *a*, cistern containing the mercury; *b*, screw in movable bottom of cistern, to raise or lower the mercury to the "fiducial" point; *c*, the vernier; *d*, the thermometer.

the decrease of pressure. When the pressure is suddenly increased or decreased beyond these points the effects are manifested. The more slowly the change is brought about, and the smaller the amount of exertion accompanying the change of pressure, the less the effect produced. Great variations from the normal atmospheric pressure are highly injurious to all persons suffering from organic disease of the heart and lungs, and to those suffering from an atheromatous condition of the arteries, because this condition prevents the arteries from readily adjusting themselves to the altered pressure, thus leading to hemorrhages. In coming out of the caisson the change in pressure must be brought about slowly. The too rapid change induces spinal hemorrhage. At least six to ten minutes should be allowed for each additional atmosphere of pressure to make the change safely. The air-locks, where the change of pressure is made, should be at the top of the shaft, and not at the bottom, so that the men are not obliged to climb the ladder when they come into the ordinary pressure.

Distribution of Atmospheric Pressure.—The barometer is high (1) when the air is very cold, for then the lower strata are denser and more contracted than when it is warm. The contraction causes the upper layers to sink down, bringing a greater number of air-particles—that is, a greater mass of air—into the column, so that the pressure at its base is greater; (2) when the air is dry, for then it is denser than when it is moist; (3) when in any way an upper current sets in toward a given area, for this compresses the strata underneath.

Conversely, the barometer is low (1) when the lower strata are heated, causing the surfaces of equal pressure to rise, and the upper layers to slide off, consequently the mass of air pressing on the area below is reduced; (2) when the air is damp, for as the density of aqueous vapor at 0° C. temperature and 760 millimeters pressure is 0.7721, air being 1, the mixture is lighter the more vapor it contains, and consequently damp air does not press as heavily as dry air on the unit of area below; (3)

when the air, from any cause, has an upward movement, for this, of course, acts in the same manner as when the lower strata are heated.

Humidity of the Atmosphere.—Atmospheric air contains more or less watery vapor at all times. The quantity of water present in the air, at any time and place, is

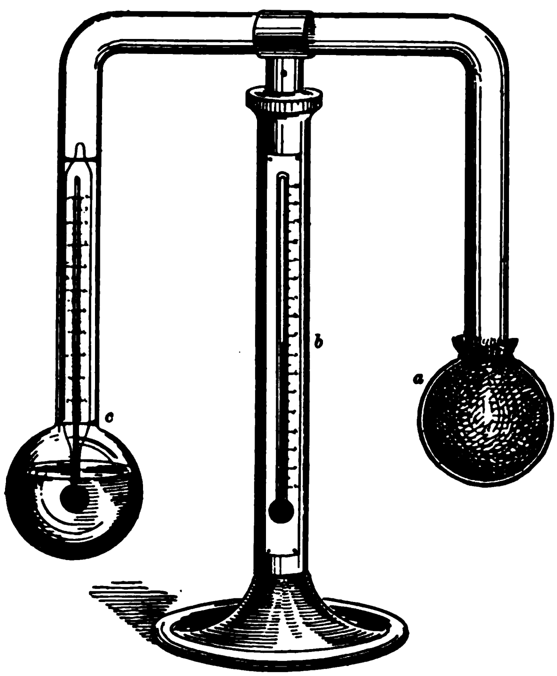


FIG. 2.—Daniell's hygrometer: *a*, bulb surrounded with cotton cloth; *b*, thermometer; *c*, bulb containing thermometer.

dependent—(*a*) upon the possibility of the air obtaining moisture from the surface of a large body of water; (*b*) upon the rate of diffusion of the moist air of the locality and its replacement by drier air; and (*c*) changes in the temperature of the air, inducing precipitation of the contained moisture. There is constant evaporation from the surface of bodies of water during sunshine. Considerable evaporation also takes place from damp soil. The degree of humidity of the air at a particular point is dependent

principally upon the rate of diffusion through which the moist air is replaced by drier air. The humidity of the atmosphere is also influenced through precipitation. Whenever the air of a locality becomes saturated with moisture and then is cooled suddenly, some of the moisture is precipitated in the form of rain, hail, or snow.

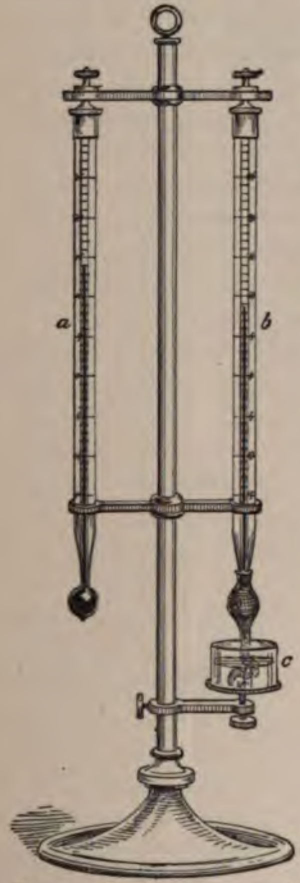


FIG. 3.—Psychrometer: *a*, dry-bulb thermometer; *b*, wet-bulb thermometer; *c*, reservoir containing water.

FIG. 4.—The hair hygrometer: *a*, *b*, point of suspension of hair; *p*, pointer; *c*, *d*, scale; *w*, weight.

Hygrometry.—Hygrometry is the determination of the amount of aqueous vapor in the air. Hygrometers are either direct, as Daniell's (Fig. 2), Dine's, and Regnault's, and determine directly the dew-point of the atmosphere; or indirect, as the wet- and dry-bulb thermometer, or psychrometer (Fig. 3), and the hair hygrometer (Fig. 4).

The important items of information to be derived from

observations with hygrometers are: The dew-point, the vapor-tension or absolute humidity, and the relative humidity of the atmosphere. The dew-point is that temperature at which the air is saturated with moisture, so that the least further fall in temperature causes a deposit of moisture in the form of dew. The higher the temperature of the air, the larger the amount of water it can contain in the form of vapor; and if the temperature be lowered, the amount of moisture remaining the same, eventually a point will be reached at which some of the moisture is precipitated. This temperature is indicated directly by the condensation hygrometers, or it can be calculated from the readings of the psychrometer, with the aid of tables or by means of Apjohn's formula:

E = elastic force of vapor corresponding to the dew-point,
e = elastic force corresponding to temperature of evaporation (wet-bulb thermometer),
t = dry-bulb temperature,
t^1 = wet-bulb temperature, and
h = height of barometer in millimeters.

$$E = e - 0.01147\ (t - t^1) \times \frac{h - e}{30}.$$

For pressures of about 760 millimeters, $\frac{h - e}{30}$ may be neglected, and the formula becomes

$$E = e - \frac{(t - t^1)}{87}.$$

For temperatures below 0° C. the formula is

$$E = e - \frac{t - t^1}{96}.$$

The tension (E) of the aqueous vapor in the atmosphere may be calculated from the readings of the wet- and dry-bulb thermometers by means of the following empirical formula:

$$E = e^1 - 0.00077\ (t - t^1) \times h,$$

in which e^1 is the maximum tension corresponding to the temperature of the wet-bulb thermometer (Ganot).

If the dew-point is known, either by calculation from

the readings of the wet- and dry-bulb thermometers, or by direct observation by means of the hygrometer, the elastic force or tension of vapor present in the atmosphere is found immediately by reference to a table of tensions.

Elastic Force of Vapor.—This is the amount of barometric pressure due to the vapor present in the air. The tension of aqueous vapor at 100° C. temperature is 760 millimeters—that is, the pressure of 1 atmosphere. At lower temperatures the elastic force of vapor is less than at 100° C. It is greatest within the tropics and diminishes toward the poles; it is greatest over the ocean, and decreases as we pass inland; it is greater in summer than in winter; it is greater at midday than in the morning; and it generally diminishes with increased elevation.

Absolute Humidity.—This is the weight of water in the form of vapor contained in a given volume of air expressed in grams per cubic meter. It varies with the temperature, and it may be computed from the readings of the wet- and dry-bulb thermometers by the use of tables.

Relative Humidity.—Complete saturation of the air being taken as 100, any degree of dryness may be expressed in percentage. The amount of aqueous vapor actually present, and the amount that would be present if the air were saturated, being known, the former is expressed as a percentage of the latter, giving the relative humidity. Relative humidity is greatest near the surface of the earth during night, when the temperature, being at or near the daily minimum, reaches the dew-point ; it is also great in the morning, when the sun's rays have evaporated the dew, and the vapor is as yet diffused only a little way upward; and it is least during the greatest heat of the day.

The Influence of Humidity on Health.—The amount of relative humidity of the atmosphere, or its complement the deficiency of saturation, is of the greatest importance. The temperature of the body is regulated by the loss of heat by evaporation from the lungs and skin.

At a temperature of 15° C., and with the relative humidity at 75 per cent., Pettenkofer and Voit estimated the loss of water from the lungs at 286 grams, and from the skin at 500 to 1700 grams daily. If the relative humidity be increased, there will be a hindrance to the escape of water from the body; and when this condition is combined with a high temperature the heat is far more oppressive than when the atmosphere is dry and allows free evaporation. On the other hand, a moist, cold atmosphere is far more distressing than when the air is dry and there is but little movement.

Movements of the Atmosphere.—The air is in constant motion as the result of changes in temperature affecting the density of the air of certain localities, the less dense or heated air being displaced by the colder, denser air. The direction in which the movement takes place is always along the line of least resistance and toward the point of less density. The rapidity of the movement is directly proportional to the magnitude of the change in density—that is, the rise in temperature. The most important cause of these movements is the relatively larger amount of heat transmitted by the sun in the tropics, which gives rise to what are known as "trade" winds. The varying amounts of heat transmitted by the sun in different latitudes and at different altitudes, and the variations in the temperature due to the revolutions of the earth on its axis, are the principal causes of winds. These movements of the atmosphere play an important part in the regulation of temperature and of the humidity of the air. If they did not occur, air would be perpetually warm in some places and perpetually cold in others. The wind carries warm air to cold regions and cold air to warm regions, thus tempering the climate of each. The wind also prevents the air from remaining excessively dry in some regions and inordinately damp in others.

The **effects of wind upon health** are complex and not well defined. All wind, or movement of the air, favors evaporation, and therefore loss of heat from the body, unless the wind itself be warm and moist; a hot,

dry wind favors evaporation but does not lower the temperature; a cold, moist wind lowers the temperature but does not increase the evaporation. Winds that are warm and moist are mild and relaxing; dry, cool winds are bracing; but cold winds are penetrating, and are considered dangerous to persons of delicate constitution.

Clouds.—When the condensed moisture of the air collects as fog in the lower strata and rises into the upper strata it takes the form and appearance which we call clouds. Clouds moderate radiation, both solar and terrestrial, and, therefore, have an equalizing influence on the temperature. Their amount is estimated from 0 (clear sky) to 10 (entirely overcast). There is most cloud in winter, in the middle of the day, and least in May and June, during the night.

Precipitation of Moisture.—The amount of cloud-formation bears a certain relation to the amount of precipitation. According to the temperature of the air, the precipitation takes place in the form of rain, snow, hail, or sleet. The amount of rainfall in a locality is dependent to a certain extent upon its vicinity to large bodies of water, upon the direction of the prevailing winds, upon the altitude, and upon the latitude. The nature and extent of the soil-covering of the locality also have a direct influence upon the amount of rainfall, as shown by the diminished rainfall in localities where the forests have been destroyed. The immediate effect of a fall of rain is to cleanse and purify the air from dust of all sorts, organic and inorganic, and from micro-organisms. Its action with regard to the micro-organisms is twofold: It not only washes them out of the air, but it tends to prevent their rising from the soil by rendering the surface of the ground moist. So far the influence of rain is decidedly beneficial to health; but when rainfall is so excessive as largely to increase the humidity of the air, its hygienic effect becomes merged in that of humidity. Also, when the amount is so great as to render the soil waterlogged its effect becomes overshadowed by the effects of a damp soil.

Climate.—By climate we understand all the meteoro-

logic conditions of a place or locality which have an influence upon health. Along with these conditions the character of the soil is also an important factor in determining and regulating the nature of the climate of a locality. Of all these conditions, meteorologic and telluric, temperature is the most important in determining the character of a climate, while humidity is the factor next in importance. Buchan states that there are four principal factors in the production of the climate of any locality: (1) Distance from the equator; (2) height above the sea-level; (3) distance from the sea; and (4) prevailing winds. Of the various classifications of climates that have been proposed, perhaps as satisfactory as any is one that rests mainly upon the first three conditions named, the fourth condition, that of the prevailing winds, introducing important modifications. Of all the factors, distance from the equator is incomparably the most potent, but irregularities in the distribution of land and water, and the prevalence of particular winds, often bring about a subversion of what Humboldt calls the solar climate of the earth. Differences of elevation also cause great differences in the climate of nearly adjacent places.

Climates may be divided into tropical, temperate, and polar; and the first two of these may be subdivided into continental, maritime, and mountain climates. A continental climate is subject to the extremes of heat and cold; has an atmospheric pressure that is normal; a moderate rainfall; slight humidity; often a clear sky; and variable winds. A maritime climate is equable—that is, without extremes of temperature; with considerable atmospheric pressure; considerable humidity; moderate rainfall; a misty or cloudy sky; winds often regular. A mountain climate has a lower temperature and less pressure than the preceding; considerable rainfall; large relative, but small absolute, humidity; sky often clear, consequently considerable terrestrial radiation and low night temperature; and winds determined by the configuration of the earth's surface.

Some idea as to the climatic conditions of different localities in the United States may be gained by refer-

Normal Temperature and Rainfall in the United States

At Weather Bureau Stations; also Highest and Lowest Temperatures ever Reported to September 1, 1899.

States and territories.	Stations.	Temperature. Mean. Jan.	Temperature. Mean. July.	Temperature. Extreme. Highest.	Temperature. Extreme. Lowest.	Mean annual precipitation. Rain and melted snow.
		° C.	° C.	° C.	° C.	Cm.
Alabama	Mobile	10.0	27.7	38.3	−18.3	157.9
	Montgomery .	8.8	27.7	41.6	−20.5	133.7
Arizona	Yuma	12.2	33.3	47.7	−5.5	7.6
Arkansas	Fort Smith . .	1.1	26.6	42.2	−26.1	113.5
	Little Rock . .	4.4	27.3	40.5	−22.2	136.1
California. . . .	Red Bluff . .	7.7	27.7	45.5	−7.7	66.2
	Sacramento . .	7.7	22.2	43.3	−8.3	53.0
	San Diego . .	12.2	19.4	38.3	−0.0	26.6
Colorado	Denver	−2.7	22.2	40.5	−33.8	36.3
Connecticut. . .	New Haven. . .	−2.7	22.2	37.7	−25.5	127.7
Delaware	Del. Breakwater.	−0.5	22.7	33.8	−17.2	82.8
Dist. of Columbia	Washington . .	−0.5	25.0	40.0	−26.1	110.4
Florida	Jacksonville .	12.7	27.7	40.0	−12.1	137.3
	Key West . .	21.1	28.8	37.7	5.0	97.7
Georgia	Atlanta. . . .	6.1	25.5	37.7	−22.2	132.0
	Savannah. . .	10.5	27.7	40.5	−13.3	131.8
Idaho	Boise	−2.2	23.3	41.6	−33.3	33.5
Illinois	Chicago . . .	−3.3	22.2	37.7	−30.5	88.3
	Springfield . .	−3.8	25.0	38.8	−30.0	96.5
Indiana	Indianapolis . .	−2.2	24.4	38.3	−31.7	109.2
Indian Territory	Fort Sill	1.3	27.7	41.6	−22.7	79.2
Iowa.	Des Moines. .	−8.3	23.7	40.0	−34.4	84.0
	Keokuk . . .	−5.0	25.0	40.0	−31.1	90.4
Kansas	Dodge	−3.8	25.5	42.2	−32.2	50.2
Kentucky. . . .	Louisville. . . .	1.1	26.1	40.5	−28.8	116.3
Louisiana. . . .	New Orleans .	12.2	28.3	37.3	−13.9	153.6
	Shreveport . .	7.3	28.3	41.6	−20.5	123.4
Maine	Eastport . . .	−5.0	15.5	32.7	−29.4	114.8
	Portland . . .	−6.6	20.7	36.1	−27.3	107.4
Maryland . . .	Baltimore . . .	1.1	25.5	40.0	21.6	111.2
Massachusetts. .	Boston	−3.3	21.6	38.3	−25.0	114.3
Michigan.	Marquette . .	−8.8	18.3	37.7	−32.7	82.2
	Port Huron. .	−6.1	20.7	37.3	−31.7	80.2
Minnesota . . .	Duluth	−12.2	18.8	37.3	−41.7	78.7
	St. Paul . . .	−11.7	22.2	37.7	−41.7	69.8
Mississippi . . .	Vicksburg . . .	8.3	27.7	38.3	−18.3	141.4
Missouri	St. Louis . . .	−1.1	26.1	41.1	−30.5	104.3
	Springfield . .	0.0	23.7	38.8	−33.8	116.0
Montana	Havre	−12.7	19.4	42.2	−48.3	35.8
Nebraska . . .	Omaha	−7.3	24.4	41.1	−35.5	80.5
	Valentine. . .	−10.0	23.3	41.1	−38.8	48.5
Nevada.	Winnemucca . .	−2.2	22.2	40.0	−33.3	21.5
North Carolina .	Hatteras . . .	6.6	25.5	33.3	−13.3	168.6
	Wilmington. .	8.3	26.6	39.4	−15.0	137.8
North Dakota .	Bismark . . .	−15.5	19.4	40.5	−42.2	46.7
	Williston . . .	−16.1	20.0	41.6	−45.0	35.5
New Hampshire	Manchester . . .	−5.5	20.7	35.5	−23.9	106.4
New Jersey. . .	Cape May . .	1.1	23.3	32.7	−19.4	119.8
	New Brunswick	−2.2	23.3	37.7	−23.3	118.8
New Mexico . .	Sante Fé	−2.2	20.0	36.1	−25.0	40.5
New York . . .	Albany . . .	−5.0	22.7	37.7	−27.7	96.2
	New York . .	−1.1	23.3	37.7	−21.1	113.7
	Oswego . . .	−3.8	20.7	37.7	−30.5	88.9

States and territories.	Stations.	Temperature.				Mean annual precipitation. Rain and melted snow.
		Mean.		Extreme.		
		Jan.	July.	Highest.	Lowest.	
		° C.	° C.	° C.	° C.	Cm.
Ohio	Cincinnati	−0.5	25.5	40.0	−27.3	101.3
	Toledo	−3.3	22.7	37.3	−26.6	78.4
Oregon	Portland	3.8	19.4	38.8	−18.8	118.8
	Roseburg	4.4	18.8	40.0	−21.1	89.4
Pennsylvania	Philadelphia	0.0	24.4	38.8	−21.1	101.2
	Pittsburg	−1.1	22.7	39.4	−28.8	93.2
Rhode Island	Newport	−1.1	21.1	33.3	−22.2	127.0
South Carolina	Charleston	9.4	27.7	40.0	−13.9	143.9
South Dakota	Yankton	−10.5	22.7	39.4	−36.6	68.0
Tennessee	Memphis	4.4	27.3	38.8	−22.7	135.3
	Nashville	3.3	26.6	40.0	−25.0	127.2
Texas	El Paso	6.6	27.7	45.0	−20.5	23.6
	Palestine	6.1	27.7	40.0	−21.1	118.1
Utah	Salt Lake	−2.2	24.4	38.8	−28.8	41.1
Vermont	Burlington	−7.2	21.6	36.1	−31.7	72.2
Virginia	Lynchburg	2.2	25.5	38.8	−21.1	108.6
	Norfolk	4.4	26.1	38.8	−16.6	132.3
Washington	Dayton	−1.1	20.0	42.7	−32.2	70.5
	Olympia	3.3	16.6	36.1	−18.8	134.8
West Virginia	Morgantown	1.6	23.3	36.1	−31.7	119.1
Wisconsin	La Crosse	−9.4	22.7	38.3	−41.6	77.9
	Milwaukee	−7.2	20.7	37.7	−31.7	81.5
Wyoming	Cheyenne	−3.8	19.4	37.7	−38.8	30.9

NOTE.—The minus (−) indicates temperature below 0 ° C.

ence to the table on pages 45 and 46, showing the mean and extreme temperature, and the mean precipitation of these localities.

The Influence of Climate on Health.—In warm climates the functions of the liver and skin are particularly active; the digestion is not vigorous, though the activity of intestinal peristalsis is often great; the nervous system is excited or depressed according to the degree of humidity of the air. In cold climates the digestive functions are vigorous; the nervous system sluggish; muscular development large; and life generally prolonged in spite of the severity of the climate. In temperate climates, which on the whole are the healthiest, there is no great strain on the liver, digestive organs, and skin as in hot, nor on the lungs and kidneys as in cold and damp climates.

A climate of a place where the air has a relative humidity of less than 25 per cent. is unusually dry, as, for instance, in desert regions where the rainfall is very low.

A relative humidity of 25 to 40 per cent. is generally regarded as dry air. A relative humidity of 40 to 60 per cent. is most agreeable and gives rise to no discomfort. A relative humidity of 60 to 80 gives a sensation of moist air, while still higher percentages of moisture are encountered in moist atmospheres. The character of a climate is, however, also influenced by the temperature as well as the relative humidity. At low temperatures, but more especially at high temperatures, the relative humidity of the atmosphere plays a most important *role* in determining the healthfulness of the climate of a locality.

Influence of Tropical Climates upon the Body.—Kohlbrügge[1] sought to determine the influence of tropical climates upon the body by means of two tests: the bleaching of the skin and the elasticity of the tissues. The bleaching of the skin of Europeans in the tropics is not always an evidence of permanent tropical anemia, as he has found it to exist in many persons in whom the blood count and hemoglobin were normal. In these instances he believes the bleaching is brought about through the influence of the free perspiration due to the high temperature and in consequence of the saturation of the superficial layers of the skin because of the hyperemia of certain vascular systems of the skin, as a result of which there is a thickening of these layers, so that the coloring-matter of the blood can no longer be seen through it. Since evaporation from the skin is inhibited because of the high atmospheric humidity, this bleaching effect remains permanent during residence in the tropics. Upon changing to a temperate climate the horny layer of the skin again becomes thinner in consequence of diminished nutrition and more ready evaporation, and the coloring-matter of the blood again becomes visible.

The tropical climate acts upon the elasticity of the tissues most probably in such a manner that the elasticity

[1] *Arch. f. Schiffs-u. Tropenhyg.*, 1900, p. 20.

of the different tissue-fibers is increased through the action of the heat. This is shown not only in natives, but also in the descendants of Europeans born in the tropics, and manifests itself in greater joint movement and in general sluggishness and relaxation.

Influence of Tropical Climate on Nutrition.—K. E. Ranke[1] made a study of the influence of climate on nutrition during a journey to South America.

The optimum temperature of the European with medium clothing is 15° to 18° C., if none of the other climatic factors produces any definite action. In a climate with a temperature of 18° to 22° C. there is increased evaporation of water, but no definite influence upon the appetite. In a climate of about 25° C., when the other climatic factors neither increase nor decrease the action of the temperature, there is a marked diminution in the appetite. With further increase in the temperature there is also further decrease in appetite, and at last it sinks below the requirements of an adult at complete rest. The protein nutrition does not sink below the maintenance minimum of the lower laboring-classes; each further diminution being made at the expense of the fats and carbohydrates. If there is opposition to this instinctive diminution of the appetite, pathologic effects manifest themselves: disturbance of the general comfort, increased temperature, and decrease of the natural resistance against infectious diseases. If the nutrition is constantly diminished below that required because of the heat elimination in a very hot climate, the deficient nutrition leads to dangerous consequences.

F. Hueppe[2] states that the dangers encountered by Europeans in the tropics in regions of less than 2000 meters' elevation are constant high temperature combined with high atmospheric humidity. These factors call forth increased efforts to cool the body, and hence affect the activity of the skin, heart, and lungs. The results of this increased activity are noticed in fatigue on

[1] August Hirschwald, Berlin, 1900.
[2] *Berlin. klin. Wochenschr.*, 1901, p. 7.

slight exertion and decreased nervous and muscular power.

The high sensibility of the digestive organs of the European in the tropics is caused by the dilution of the digestive fluids from increased ingestion of fluids induced by the free perspiration. All these conditions vary in different individuals. General exercise, especially in the form of riding and swimming, is beneficial for all the body functions. The tropical climate operates especially unfavorably upon the female organism.

The Australian Institute of Tropical Medicine,[1] in studying the effects of tropical climates on Europeans, found that on walking two miles the body temperature rose from 2° to 3° F., the blood-pressure rose from 10 to 20 mm. of mercury, and the pulse-rate from 20 to 37 during the first mile, but that during the second mile the temperature and pulse showed a much slighter increase and the blood-pressure a light decrease. These effects are attributed to the humidity and atmospheric temperature interfering with heat elimination.

The greatest enemy of the European in the tropics is alcohol, the misuse of which increases enormously all the other unfavorable and detrimental influences. The infectious diseases, as yellow fever, cholera, plague, dysentery, and malaria, are the next greatest detrimental influences in the tropics.

The influence of climate upon the course of certain diseases has been the subject of numerous observations. The influence of a dry climate upon the course of tuberculosis is now well understood. The rarefied air as found in the Rocky Mountain region seems to be of great value in the treatment of this disease. This condition of the atmosphere produces an augmented respiratory activity which is highly beneficial in early stages of consumption.

The value of pine forests in localities having a dry, sandy soil and a climate of low relative humidity is also generally recognized. The pine belts of New York,

[1] *Jour. Amer. Med. Assoc.*, vol. lxxiv, 1588, 1920.

New Jersey, and North Carolina are especially adapted for consumptives during the winter months of the year.

Probably the chief value of removal to another climate in the early stages of consumption is to be traced to the changed conditions of life. The outdoor life which these localities usually permit, along with the high percentage of clear days, and the removal from the anxieties and constraints of business life, are as beneficial as the climate itself, if not more so. The conviction that this is the case has led a number of prominent physicians to advocate the high plateaus of the Blue Mountains in eastern Pennsylvania as a desirable locality for the recuperation of those likely to be benefited by change of climate. The locations which have been specially advocated are Pocono Mountain in Monroe County and Green Mountain in Lehigh County. This region is the natural home of the pine, though the operations of the lumbermen have long since caused its almost total disappearance. The State of Pennsylvania is acquiring a number of large areas of land in different parts of the State for forest reservations, and in time these will be valuable localities for the establishment of institutions for the climatic treatment of diseases similar to those found in the Adirondack region of New York and elsewhere.

Sanitoria for the treatment of incipient and advanced cases of tuberculosis are now maintained by the State of Pennsylvania at Mont Alto in Franklin County, at Cresson in Cambria County, and at Hamburg, Berks County.

Influence of Climate and Season on Mortality.— The seasonal variations alone in the temperate zone are of great influence upon mortality aside from the general climatic conditions of a locality. Mild winters and cool summers both lower the mortality, the former exerting a special influence upon the aged, and the latter upon the young, more particularly the infantile population. A cool, damp summer is always accompanied by a low mortality. Season has also an important influence upon the character of the prevalent diseases—intestinal diseases

being most prevalent in summer and respiratory diseases in winter. Typhoid fever is least prevalent in late spring and early summer, and most prevalent in the autumn. Typhoid fever reaches its mean about the end of the year; then there occurs a gradual fall to a minimum in April, sometimes interrupted by a slight outbreak in January or February. There is also a June or July minimum with a more rapid rise to maximum about the end of October or beginning of November. The curve of scarlet fever is very similar to that of typhoid fever, but its minimum is in March, and it rises gradually to a maximum early in November.

Acclimatization is that process by which animals or plants become adapted to, and so thrive in, a climate different from that in which they are indigenous. For instance, almost all the domestic animals were originally natives of warm climates. As regards man, Arnould states that the race is acclimatized when it preserves (1) the natural increase in population; (2) its normal longevity; (3) its aptitude for physical and intellectual work. He gives the following as conditions favorable to the acclimatizing process: 1. Slight alteration in the latitude: to proceed from a warmer to a colder climate is an advantage. 2. Ethnical disposition. 3. Manners and customs. It is essential to adapt one's diet to the climate. Clothing and general habits should also be assimilated to the altered conditions of climate. 4. Aptitude for cross-breeding. 5. Soil and locality: where the soil is not unhealthy, acclimatization is much simplified; if an unhealthy soil is made healthy, by drainage, etc.

It is evident that a large part of the influences attributed to changes in climate is in reality due to the prevalence of certain diseases in different localities which are absent in others. For instance, those passing from the temperate zone into the tropical zone encounter diseases which are unknown in the temperate region, and for which they possess neither a congenital nor acquired immunity and hence are highly susceptible to such infections. After they have acquired an immunity against such diseases, it

is probable that the more important feature of their acclimatization has been accomplished.

Ground-air.—The atmosphere does not stop at the surface of the soil, but penetrates into all the pores and crevices. The proportion of air in the soil is not great where there are no fissures or clefts, but in the superficial layer air is always present in appreciable proportions, and especially so in made soil. Soil-air is of somewhat different composition than the atmospheric air. We find present in it large quantities of the products of putrefaction, which is very active in the soil. It is, therefore, far richer in carbon dioxid, besides containing other hydrocarbons as the result of putrefaction, principal among which is marsh gas. In subterranean caverns the air may have undergone such an amount of change as the result of putrefaction and chemical changes going on in the rocks that it is not fit for respiration, and may be highly inflammable as the result of the admixture of other gases. Soil-air is therefore injurious if inhaled in large quantities and for a long time. It tends to penetrate into houses from the surrounding soil, because the warmer air of the house has an upward tendency and thus abstracts the air from the soil. For this reason newly made soil is considered unhealthy and should be avoided. This is especially the case with the newly made soil in and around cities, where the materials employed in making the soil are frequently such as are capable of undergoing putrefaction.

Sewer-air.—Sewer-air in properly constructed modern sewers is merely atmospheric air which contains a slight excess of carbon dioxid and small amounts of gases resulting from putrefaction taking place in the sewage. Consequently there is also a slight decrease in the proportion of oxygen present. The proportion of micro-organisms is usually less than that of the air of streets and houses, and they are usually harmless species. The movement of air in sewers is rather slow, and affords abundant opportunity for the suspended particles, along with the micro-organisms, to become deposited on the

moist walls of the sewer. When a portion of a sewer or the drainage-pipes of a house become obstructed, so that there is no longer a free circulation of air in the obstructed portion, then there is an accumulation of the gases resulting from putrefaction, such as carbon dioxid, hydrogen sulphid, marsh gas, etc., and these gases are highly injurious when inhaled in considerable quantities or in smaller amounts for a considerable time.

The Impurities in Air.—These are either gaseous or solid. The more important gaseous impurities in air are carbon monoxid and dioxid, marsh gas, hydrogen sulphid, gaseous organic substances—such as amins, ammonia, and volatile fatty acids. The solid impurities in air are various forms of dust, inorganic and organic; the débris of vegetable and animal organisms, and living micro-organisms.

Sources of the Impurities.—*Impurities due to Respiration.*—The changes that take place in air that has been respired are both chemical and physical. (1) The volume of the expired air is from one-fiftieth to one-fortieth less than that taken in at the corresponding inspiration. (2) The temperature is raised, as a rule, to about 36° C. (3) Owing to this rise in the temperature there is actually an increase in volume of the expired over the inspired air to an extent of about one-ninth of the latter. (4) There is an increase in the amount of carbon dioxid to between 4 and 5 per cent. (5 and 6) There is an increase of ammonia and watery vapor. (7) The nitrogen is generally increased, but sometimes diminished. (8) The oxygen is diminished to about 16 per cent. There is an addition to the air of (9) hydrogen, (10) marsh gas, and (11) organic matter. Of these alterations, the most important are the increase in the amount of carbon dioxid and the corresponding decrease in the amount of oxygen, the increase of the aqueous vapor, and the addition of organic matter.

Carbon Dioxid.—The amount of carbon dioxid excreted has been variously estimated at from 31.5 to 37.5 grams per hour. According to Pettenkofer and Voit, the

total amount excreted in twenty-four hours for male adults is, on an average, 800 grams, or 406 liters; and according to Vierordt, 900 grams, or 455.5 liters. Assuming the tidal air of each respiration to measure 500 cubic centimeters, and to contain 4 per cent. of carbon dioxid, and that 17 respirations are taken every minute, then the carbon dioxid excreted in one hour is $500 \times 0.04 \times 17 \times 60 = 20.4$ liters, or 489.6 liters in twenty-four hours.

Aqueous Vapor.—The expired air contains considerable quantities of aqueous vapor. The absolute amount varies with the temperature of the expired air; but this itself varies very slightly, being nearly that of the blood, ranging from 33.8° to 36.1° C.[1] According to Vierordt, 330 grams of water are given off from the lungs in twenty-four hours; and according to Valentine, 640 grams. Pettenkofer and Voit state that, with the temperature of the atmosphere at 15° C. and the relative humidity at 75 per cent., an adult gives off 286 grams of water from the lungs in twenty-four hours.

Organic Matter.—That organic matter is present in the expired air is obvious from its odor, which is often quite fetid, and from the fact that when it is collected by the condensation of the aqueous vapor it is putrescible. It has been supposed by some that this organic matter is derived from the alimentary canal and from the upper portion of the respiratory tract, but it has apparently been found in air drawn directly from the trachea. The greater portion of it, however, arises from decomposing particles of food lodged between the teeth, and only a small portion of it comes directly from the lungs. A small portion of it is also derived from the mucous membrane of the pharynx and larynx and, probably, from the stomach.

The nature of the organic matter is not known with certainty. It decolorizes solutions of potassium permanganate, and is, therefore, capable of being oxidized. When distilled it is broken up and yields ammonia, and is, therefore, nitrogenous. It is molecular rather than

gaseous, and is probably in combination with water, because those substances which are most hygroscopic absorb most organic matter. The quantity of organic matter given off with the expired air has been estimated. Cornelly, Haldane, and Anderson found, in ten observations, that the amount of oxygen required to oxidize the organic matter varied from 1.7 to 13.6 milligrams per liter of condensed vapor, giving an average of 7.6 and 8.3 milligrams for two observers, respectively. Lehmann and Jessen found that between 3 and 4 milligrams of oxygen were required to oxidize the organic matter in a liter of condensed vapor. Ransome's results indicate the exhalation of 20 milligrams of organic matter in twenty-four hours, and Beu's results, 15 milligrams. In my own experiments[1] I found the quantity of organic matter in the expired air of healthy men to be, on an average, 10.72 milligrams per liter of condensed vapor. I found also that the amount of organic matter is much greater three to four hours after a meal than immediately after eating, and, likewise, that the amount is directly dependent upon the degree of cleanliness of the mouth and teeth of the person from whom the vapor is collected; the average amount four hours after meals was 11.98 milligrams, half an hour after meals it was only 3.86 milligrams when the mouth and teeth had remained uncleaned for several days, while the average, four hours after meals, was only 2.49 milligrams when the teeth had first been brushed and the mouth thoroughly rinsed with warm water. The amount of organic matter is also greater in those having decayed teeth than in those having sound teeth. In vapor condensed from the breath of a man having an opening directly into the trachea, and in whom there was no communication between the trachea and pharynx, I found the average for three observations to be 9.68 milligrams. In a consumptive person I found the average amount to be 17.34 milligrams. I found the average amount of nitrogenous organic matter given off with the expired air to be 17.5

[1] *Smithsonian Contributions to Knowledge*, 989, Washington, D. C., 1895.

milligrams of free, and 9.0 milligrams of albuminoid, ammonia per liter of condensed vapor, for healthy persons; and 0.3 milligram of free, and 3.4 milligrams of albuminoid, ammonia in that of consumptive persons.

Bacteria in Expired Air.—No bacteria are given off with the expired air in ordinary, quiet respiration. In the forcible expirations during speaking, coughing, or sneezing it has been found that small particles of mucus and moisture are thrown off which carry microorganisms. In this manner a person suffering from the various infectious diseases may infect the atmosphere and the furniture of the room in which he lives. It must be remembered, however, that only in several diseases which are localized in the respiratory tract would there be danger of the dissemination of the specific disease-producing bacteria. This mode of dissemination may take place in tuberculosis of the respiratory tract, in diphtheria, and in pneumonia. In those diseases in which the specific bacteria are localized in some other part of the body there would be no danger of their dissemination through coughing, speaking, etc.

Persons who have recently recovered from diphtheria or from some other disease of the upper respiratory tract, or persons who have been in close contact with patients suffering from infection of the upper respiratory tract may carry the infecting bacteria in their throat for some time. These so-called "carriers" are likely to contaminate the air or infect the furniture in a room in the same way as do those actually suffering from disease.

Impurities due to Perspiration.—The secretions of the skin consist of sweat proper (an acid, watery fluid containing about 1.8 per cent. of solids) and of sebaceous matter, and the quantity varies greatly according to the temperature and humidity of the air, the amount of exertion, etc., but may be taken as ranging from 800 to 1000 cubic centimeters during twenty-four hours. Epithelial cells are constantly disengaged from the skin. Considerable amounts of carbon dioxid are also given off through the skin.

Impurities Due to Combustion.—The principal impuri-

ties due to combustion are carbon, carbon monoxid, carbon dioxid, sulphur, sulphur dioxid, sulphuric acid, sometimes hydrogen sulphid, ammonia compounds, and water.

The impurities arising from illuminating-gas are olefiant gas and other hydrocarbon vapors, hydrogen, carbon monoxid, and marsh gas. Besides these normal constituents of the gas we frequently find present carbon dioxid, hydrogen sulphid, and other sulphur compounds.

Impurities in the Air of Work-rooms and Factories.—The air of work-rooms and factories contains the impurities arising from the respiration and perspiration of the occupants, and, in many instances, also the products of combustion arising from the process of heating and lighting. Such rooms are often overcrowded and overheated, and in consequence these impurities are present in excessive amounts, while from lack of personal cleanliness there is a greater proportion of the organic impurities arising from perspiration.

The special impurities of the air resulting from the manufacturing processes present one or the other of the following conditions: (*a*) Increase of temperature, as in mines or bake-houses, the "gassing" rooms of silk mills, and the "sizing" sheds of cotton mills. (*b*) Excessive humidity, as in some deep mines and in the "sizing" sheds of cotton mills. (*c*) The presence of deleterious gases; in mines carbon monoxid and dioxid, carburetted hydrogen and hydrogen sulphid may be present; in bleaching works sulphur dioxid is evolved, and also in copper works, though in the latter it at once passes into the outer air. (*d*) Vapors of hydrochloric, sulphuric, and nitric acids, and of chlorin are given off in certain processes of the manufacture of steel. (*e*) Carbon disulphid is present in the air of vulcanized India-rubber works. (*f*) The fumes of phosphorus in match-making, and (*g*) the fumes of zinc in brass founding; (*h*) arsenical fumes in copper-smelting, the preparation of wall-paper, the manufacture of artificial flowers, and in the preparation of skins for mounting; and (*i*) mercurial vapors are given off in bronzing and gilding, and in the manu-

facture of artificial flowers; (*j*) the fumes of lead and lead oxid dust in the manufacture of electric storage-batteries.

Impurities in the Air of Dwellings.—The impurities in the air of houses are those arising from respiration, perspiration, and combustion, and, in addition, arsenical vapors may be present when the walls are covered with paper containing arsenic. In cities the air of houses may also contain impurities arising from sewers or from cesspools.

Dust in the Air.—The most injurious constituent of the air in certain manufactories and in the air of the streets of cities is dust. Mineral dust is given off in certain manufacturing processes and in mines. This is especially injurious in establishments where cutlery and files are made, also in gun factories. Dust of vegetable origin is given off in the wood-working manufactories. The hard woods used in cabinet-making are especially injurious. In factories where hides and feathers are used dust of animal origin is found. In the arrangement of modern manufacturing establishments much of the danger from dust particles is overcome by special arrangements, by means of which the dust is extracted from each machine and is removed by a special flue by means of a strong current of air.

Examination of the Air by the Senses.—Immediately on entering the place where the air is to be examined, note the condition of the air as presented to the olfactory sense. Note whether it is fresh and sweet, rather close, very close, or fetid. The odor of animal organic matter when present in the air, even in small amounts, is very offensive and readily detectable, if the *first* impression on entering be noted; after half a minute this impression wears off. The readiness with which it is perceived depends largely on the humidity of the air, more so than on the increase of the temperature. A rise of 1 per cent. in the humidity has as much influence on the condition of the air, as judged by the sense of smell, as a rise of 2.32° C. in the temperature.

The recognition of the presence of organic matter in

the air is the most important item of information to be gained by the senses; but the presence of illuminating-gas or any abnormal smell should, of course, also be noted, as well as the humidity of the air and the presence of notable quantities of dust.

Chemical Analysis of Air.—This includes, first and most important, the determination of the proportion of carbon dioxid, since this is commonly taken as an index of the other impurities in the air; second, the estimation of the humidity of the air; and, third, the determination of the quantity of oxidizable organic matter, as shown by the potassium permanganate test. A more complete chemical analysis would include the estimation of the amount of oxygen present, the amount of ammonia (free and albuminoid), the amount of nitrous and nitric acids, of hydrogen sulphid, etc., in the air.

The proportion of carbon dioxid in the outside air should always be determined at the time when the air of an enclosed space is being examined. The excess of carbon dioxid in the inside air over that in the outside air is termed the "respiratory impurity" of the air. When, however, it is impossible to analyze the outside air, 0.4 may be taken as the average content of carbon dioxid per 1000 volumes of air.

Estimation of Carbon Dioxid in Air.—It has long been the custom to gauge the relative purity of the atmosphere of confined spaces by the determination of the proportion of carbon dioxid present. It has been shown that all the impurities of the air arising from human occupation increase in a fairly constant ratio, and that the estimation of the proportion of carbon dioxid in such air is indicative of the corresponding increase of the other impurities, such as organic matter, ammonia, moisture, etc. Moreover, on account of the relatively greater simplicity and accuracy of the methods of estimating the carbon dioxid the determination of the carbon dioxid content of air is generally employed in estimating the purity of an atmosphere.

The methods employed in the laboratory for the estimation of the carbon dioxid content of air have been

devised by von Pettenkofer. Of the two methods devised by von Pettenkofer, that known as the flask method is the more serviceable. In both methods a solution of calcium, barium, or strontium hydroxid, of definite strength, is exposed to a known volume of air in a tared flask so as to combine the carbon dioxid with the basic hydroxid to form the corresponding carbonate. The subsequent titration of a portion of the alkaline solution with an acid solution of known strength shows the amount of the alkaline hydroxid that has been neutralized by combining with the carbon dioxid of the air.

In the flask method the air is forced into a four-liter bottle, the capacity of which has been accurately determined, by means of a hand bellows. When the bottle has been filled with the air to be examined, it is closed with a rubber cap. The alkaline hydroxid solution is now introduced by carefully lifting the rubber cap and again replacing it. In the von Pettenkofer tube method the alkaline hydroxid solution is placed in a specially constructed tube through which the air to be examined is slowly aspirated.

When the carbon-dioxid content of the air is to be determined at points away from the laboratory it is desirable to use a portable apparatus such as has been devised for this purpose by Haldane or that of Peterson-Palmquist. These forms of apparatus permit one to analyze only a small sample of air, and hence the results are less reliable than where larger samples are used, as in the Pettenkofer methods. Because of the small samples used extreme care is required in the measurement of the sample air, as well as to avoid any changes in the temperature of the sample of air.

Estimation of the Humidity of Air.—The relative humidity of the air of a room is most readily determined by means of a sling psychrometer. Fairly satisfactory results can be obtained by means of a properly managed stationary psychrometer (Fig. 3), or with the hair hygrometer (Fig. 4, p. 39).

Estimation of the Organic Matter in Air.—The proportion of organic matter can only be determined indirectly, either by estimating the amount of oxygen required for its oxidation, or by determining the amount of nitrogenous

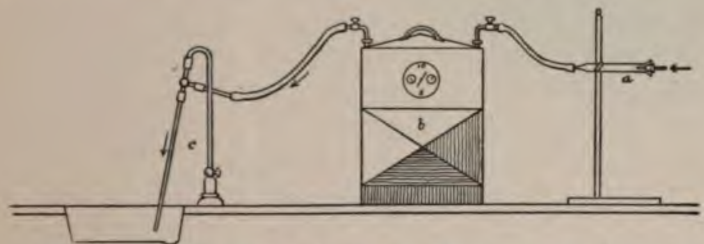


FIG. 5.—Apparatus required with this method. It consists of: *a*, a small glass tube, twenty centimeters in length, consisting of a narrow portion four centimeters long and three millimeters in its internal diameter, and a dilated portion sixteen centimeters long and twelve millimeters in its internal diameter. This tube contains the granular pumice-stone which serves as the absorbent material in this method; *b*, is the gas-meter; and *c*, a Chapman water pump.

organic matter from the quantity of free and albuminoid ammonia obtained through distillation.

Thus far the methods devised for the estimation of organic matter in air have not proved very satisfactory. One of the principal reasons for this fact is the necessity of very careful manipulation to avoid unusually large experimental errors. The method which has given most satisfactory results in my hands[1] is that devised by Remsen (see Fig. 5), in which the air is aspirated through a small glass tube containing freshly ignited pumice-stone which has been moistened with twice-distilled water. After a definite volume of the air has been drawn through such a tube, the amount of organic matter adhering to the pumice-stone is determined either by the Wanklyn method as free and albuminoid ammonia, or by boiling with permanganate of potash solution as in the estimation of oxidizable organic matter in water.

It is often desirable to determine the amount of dust as well as the nature of the dust in air. A method for the enumeration of the dust particles in air has been devised by Aitken, but the method devised by

[1] Smithsonian Miscellaneous Collections, No. 1037, 1696.

the New York Commission on Ventilation for estimating the amount and nature of dust in the air has many advantages over Aitken's method, since it permits the enumeration of the number of dust particles, a determination of their relative size, chemical composition, as well as the number of bacteria contained in the air. Samples of from 1000 to 5000 liters of air, depending upon the amount of dust contained in it, may be collected, and in this way a fair estimation of the condition of the air may be made.

Diseases Produced by Impure Air.—Carbon Dioxid.—This gas is poisonous in proportions exceeding 1 or 2 per cent.; but there is no doubt that the constant presence of even smaller amounts for long periods of time induce a progressive depression of the vitality, thus constituting a preparation for, and a predisposing cause of disease. The bad effects produced by breathing air vitiated by respiration are in part, though not entirely, due to the contained carbon dioxid.

Carbon Monoxid.—This is a powerful narcotic poison. Its poisonous action depends on the formation of a new and quite stable compound with the hemoglobin of the blood, the oxygen being entirely displaced. It produces unconsciousness, paralysis of the heart, and, at high temperatures, convulsions. Small quantities cause headache, giddiness, and speedy insensibility. A mixture of carbon monoxid and dioxid seems to be more poisonous than the monoxid alone.

Hydrogen Sulphid.—This gas acts as a narcotic poison; 1 volume per 1000 volumes of air being fatal to dogs. The chronic effects produced by the inhalation of small quantities are depression, digestive disturbances, and anemia, with narcotic or convulsive symptoms in more acute and severe cases.

Effects of Vitiated Air Generally.—Vitiation by Respiration and Perspiration.—It is impossible to separate the effects produced by these two forms of vitiation from one another, nor is it necessary, as they always coexist. In addition, the emanations from the alimentary tract are also a possible source of impurity. The

effects produced by vitiated air of this character may be divided into two classes, those of extreme vitiation acting for a short time, and slighter vitiation extending over a long period of time.

Extreme vitiation for a short time, as produced by great overcrowding, may cause death from deficiency of oxygen and excess of carbon dioxid in the air breathed. It was supposed until recently that a large share of the effects produced by such an atmosphere was traceable to the organic matter present in expired air, but at present there is no convincing evidence that such is the case. On the other hand, the experiments on animals indicate that deficiency of oxygen, excess of carbon dioxid, increased temperature, with high relative humidity of the air, are the principal factors in producing the effects. The increased temperature, high relative humidity, and lack of movement of the air are the most important factors in producing the effects through their operation upon the heat-regulating functions of the body.

Experiments on human beings confined in a small air-tight chamber have demonstrated that when the degree of vitiation has become sufficiently great to induce marked discomfort in the occupants, the discomfort disappears very quickly when a fan is set in motion and the air brought into active circulation. That the discomfort is due to interference with evaporation from the skin is shown by the fact that a person confined in such a room, but breathing fresh outside air, experiences an equal degree of discomfort to those in the room, and by the fact that a person outside the room, with his body exposed to fresh air but breathing the air of the room, experiences no discomfort.

These experiments show that vitiated air may be breathed for a considerable time without experiencing discomfort or apparent injury so long as the air is kept in motion, so as to favor a sufficient amount of evaporation from the surface of the body. If a person were confined in such an atmosphere for some time the effect would, no doubt, be highly injurious.

Slighter vitiation of the air when continued for some

time causes anemia, weakness, and general depression of the vital forces, nutrition being gravely interfered with. Pulmonary affections appear to be produced, either directly or indirectly, by causing a predisposition to them. Such conditions of the air are met with in confined workshops and in overcrowded schools. In many instances the effects of breathing impure air are complicated with the sedentariness of the occupation and its consequent interference with the normal functions of the body; poverty and insufficient nourishment being frequent concomitants. It is a matter of fact that headache, malaise, want of appetite and of energy, are caused by habitual breathing of impure air.

The prevalence of certain diseases of the lungs in those constantly breathing impure air indicates a causative relation. The prevalence of phthisis among soldiers and sailors was considered to be due to impure air by Parkes and many other competent observers. With the improvement of the ventilation of their quarters phthisis has diminished. Notwithstanding the indications, impure air is not directly the cause of phthisis; only indirectly, through the lowered vitality it produces and the facilities it affords for the transmission of the specific micro-organism. The reduction in the number of cases of phthisis among soldiers and sailors resulting from improvement in the ventilation of their quarters is brought about through the increased vitality induced, and through the greater dilution of the impurities in the air—the tubercle bacilli—and, in consequence, the facilities for their transmission are less favorable. The prevalence of pneumonia also appears to bear some relation to the degree of purity of the respired air. This relation is shown in the lowering of the incidence of pneumonia in soldiers where the air space and the ventilation in barracks has been increased. The same favorable effects were seen in laborers who had been housed in crowded quarters, as in the Rand miners in South Africa.

Effects of Air Vitiated by Combustion.—Generally speaking, the gaseous products of combustion are diffused

so rapidly that there is no prejudicial effect on health; but in some instances, as in crowded work-rooms, where much gas is burned, and in hot, crowded places, such as theaters, the effects are obvious and not to be disregarded. The effects produced by such air when inhaled constantly are anemia, vital depression, headache, and sometimes gastric derangement when the exposure is only for a few hours.

In air vitiated by the combustion of illuminating gas distinct oppression is noticeable when the proportion of carbon dioxid has increased to 3 to 4 parts per 1000, while the addition of similar amounts of *pure* carbon dioxid to air has no such effect and is practically indistinguishable from pure air. A corresponding deficiency in the oxygen of the air is also without sensible effect. In coal-mines the slow oxidation of the coal brings about an accumulation of carbon dioxid to the extent of 5 to 10 parts per 1000, with a corresponding decrease in the oxygen, yet such air is indistinguishable from pure air. The effects of air vitiated by combustion of illuminating gas has been traced to the presence of sulphur by Dr. Haldane. Sulphureted hydrogen and carbon disulphid are contained in crude illuminating gas and may be present in the proportion of 1 gram per cubic meter (40 grains per 100 cubic feet), and in such amounts exert a distinct depressing influence upon the occupants of a room illuminated with the gas. By passing the crude gas over quicklime, sulphid of lime, hydrated oxid of iron, or manganese dioxid, the sulphur compounds are absorbed and the purified gas contains only 0.2 gram of sulphur per cubic meter (8 grains per 100 cubic feet).

Gasoline Engine Gas-poisoning.—A number of fatal gas-poisonings have occurred in closed garages and in other places where gasoline engines are used. The poisons apt to be present under these conditions are gasoline fumes and the products of more or less incomplete combustion of gasoline.

The effects of various proportions of these poisons are as follows[1]:

[1] *The Ohio Public Health Journal*, vol. vii, p. 30, 1916.

Gasoline (naphtha, benzine, petroleum benzine):

0.02 gram per liter of air will cause local symptoms.

0.05 gram per liter of air is poisonous.

Carbon dioxid:

4 per cent. will cause distress symptoms.

10 per cent. will cause death.

Carbon monoxid:

0.05 per cent. is slightly poisonous.

0.25 per cent. is dangerous to new workers.

0.50 per cent. is the limit for habitual workers.

Solvent naphtha No. 1 (90 per cent. distilled over at 160° C.):

0.036 gram per liter poisons dogs in thirty minutes.

Solvent naphtha No. 2 (90 per cent. distilled over at 175° C.):

0.048 gram per liter poisons dogs in sixty minutes.

Benzol:

0.015 gram per liter of air will cause marked symptoms in rabbits.

0.042 gram per liter of air will kill dogs in twenty minutes.

Effects of Solid Impurities in Air.—The solid impurities in the air may produce irritation of the mucous membrane of the respiratory tract and lead to bronchitis and laryngitis. The effects of the solid impurities are most frequently seen in those following certain occupations, as in coal-mining, cotton-weaving, emery-grinding, polishing of metals, etc.

In the pottery trade the workmen are exposed to dust, and as a result emphysema is quite common, and is known as "potters' asthma." Grinding of steel, especially of the finer tools, is very dangerous unless wet-grinding is employed or proper ventilation is introduced. The makers of pearl buttons suffer from chronic bronchitis. In the textile industries the fine particles of wool, flax, and cotton floating in the air are injurious. The makers of matches are not infrequent sufferers from phosphorus-poisoning.

CHAPTER II.

VENTILATION.

By the term *ventilation* we understand the continuous introduction of pure air into a room or building, thoroughly mixing it with the contained air, and the simultaneous extraction of a like quantity of impure air. The ventilation of rooms and buildings is necessary in order to prevent the accumulation of the impurities of respiration, perspiration, and combustion.

Diffusion of Gases.—The principles employed in ordinary ventilation depend upon a property common to all gases—that of diffusion. Gases which have no chemical affinity for each other will mingle regardless of their relative weight or density, and form a perfectly uniform mixture. The time required for the diffusion of gases is inversely proportional to the density, and directly proportional to the square root of the absolute temperature.

Amount of Fresh Air Required.—*Amount of Fresh Air Respired.*—The quantity of air taken into the lungs by an adult person at each ordinary inspiration averages 500 cubic centimeters. Assuming that 17 inspirations are taken each minute, the total amount of air inspired in twenty-four hours is 12,240 liters. About 5 per cent. of the oxygen contained in the inhaled air is absorbed. If 17,000 liters of air are inhaled in twenty-four hours, 850 liters, or 1200 grams, of oxygen are absorbed. These figures are based on results obtained when a fair amount of exercise is taken. A man of average weight excretes 17 liters of carbon dioxid per hour in repose, 25.5 liters with gentle exertion, and 51 liters with hard work. Weight for weight, children give off about twice as much carbon dioxid as adults.

The Standard of Purity.—The air under ordinary conditions contains about 0.4 part of carbon dioxid per 1000 parts, and the standard of purity for the air of dwellings is not to exceed 0.6 part in 1000, thus allowing an excess of 0.2 part per 1000 as "respiratory impurity." The amount of fresh air required in order to maintain the standard of purity in the air of dwellings can be very readily determined, provided we know the velocity with which the air enters, the size of the openings, and the number of persons in the room.

If we take the proportion of carbon dioxid in the air as an index of the character of the ventilation, the method of calculating the amount of fresh air required to maintain the standard of purity is based on the following data: The amount of carbon dioxid exhaled per head per hour, and the ratio per 1000 of respiratory impurity. The calculation is made according to the formula $\frac{e}{r} = d$, where

e = the amount of CO_2 expired, in liters, per head per hour,
r = the ratio per 1000 of CO_2—the permissible limit due to respiratory impurity, and
d = the delivery of fresh air per hour, expressed in cubic meters.

Example 1: Let $e = 17$ liters, the average amount for a mixed audience in repose, and $r = 0.2$ volume per 1000, then $17 \div 0.2 = 85$ cubic meters or 85,000 liters of fresh air per head per hour.

Example 2: With gentle exertion an adult man excretes 25.5 liters of carbon dioxid per hour. Then the formula $\frac{e}{r} = d$ becomes $\frac{25.5}{0.2} = 127.5$ cubic meters or 127,500 liters per head per hour. It has been found that the amount of air required per hour, in liters, is as follows:

	In repose.	Gentle exertion.	Hard work.
Adult males . . .	85,000	127,500	255,000
Adult females . . .	57,000	85,000	170,000
Children	42,500	63,750	113,000

For muscular adults a larger amount of fresh air must be supplied than the average amounts given. A larger amount should also be supplied for the sick than for the healthy; an increase of one-fourth of the air-supply being

necessary for hospitals, or 106.25 cubic meters, or 106,250 liters, per head per hour.

The amount of carbon dioxid given off by school children may be assumed to be 10 liters, for a candle 15, for a petroleum lamp 60, and for a gas flame 100 liters; consequently in artificially lighted rooms additional space must be provided to prevent the accumulation of an excess of carbon dioxid. The amount of additional ventilation required for each form of illumination can be calculated in the same manner as already indicated by substituting the corresponding amounts of carbon dioxid yielded by each; for instance, a gas flame would require $\frac{e}{r} = d$, where $e = 100$, instead of 17, as in the first *example* given.

According to Hueppe, the degree of pollution of the air through different causes may be determined by taking into consideration the amount of carbon dioxid, heat, and watery vapor given off by a person or by any of the more common sources of illumination. The necessary data are contained in the following table:

	Development of CO_2 per hour in liters.	Heat in calories.	Watery vapor, in grams per hour.
Child	10.0	52	20
Youth	17.0	90	40
Man, resting	20.0	130	60
Man, working	36.0	255	130
Candle	15.0	106	10–12
Petroleum lamp	56–61	430–580	35–40
Oil lamp	31–56	200–390	26–40
Gas light, flat burner	90	600–875	130
Gas light, Argand burner	109	800–900	157

Cubic Space.—The amount of cubic space provided for each person depends to some extent on the nature of the occupation, and on the ease with which the contained air can be replenished. If 85 cubic meters of fresh air are to be supplied per head per hour, it is obvious that this can be more readily effected in a room of 25 cubic meters capacity than in one of only half the capacity

without producing disagreeable draughts. The velocity of the incoming air, the position and size of the inlet openings, as well as the temperature of the incoming air, must be so regulated as to prevent the sensation of draught.

It has been found that in temperate climates the air can be changed satisfactorily only about three times an hour unless it is introduced at a temperature above 18° C. In order that 85 cubic meters of air may be supplied, the cubic space for each person should be about one-third as large, or 28.3 cubic meters. For hospitals and sick-rooms the cubic space must be increased in the same proportion as in the fresh air-supply by about one-fourth, so as to provide a space of 35 to 37 cubic meters per head. For cases of infectious diseases a still larger space should be provided. In schools, as a rule, the cubic space provided is very small in proportion to the space required theoretically. In the schools of France and England the cubic space per head ranges from 2.83 to 4.675 cubic meters. In the modern school buildings of Philadelphia only about 5.6 cubic meters are provided for each pupil, and the air is changed about seven times an hour. With the modern systems of ventilation now in use this amount of space is possibly not much too low to meet the desired results.

According to Morin, we require—

	Amount of ventilation in cubic meters per hour per person.	Maximum cubic space.
For hospitals	60–100	30 –50
For prisons	50	25
For factories	60–100	30 –50
For barracks	30– 50	15 –25
For theaters	40– 50	20 –25
For halls and assembly-rooms	30– 60	15 –30
For schools	15– 20	7.5–10
For class-rooms for adults	25– 30	12 –15

It will be noted that Morin allows for a complete change of air only twice each hour. Where more frequent changes of air can be definitely secured a smaller

amount of cubic space per person may give satisfactory results.

General Rules for Ventilation.—The quality of the incoming air is of equal importance with the quantity; therefore, care must be exercised in selecting the source of the air-supply. In large towns it may be necessary to wash or filter the air before it is distributed.

The current of incoming air should be imperceptible. This is of special importance when, as is generally the case, the temperature of the outside air is lower than that of the air of the building. When cold draughts are produced the system of ventilation is faulty. The larger the area of the inlet and the outlet openings the slower the velocity of the air current, but obviously these openings cannot be enlarged indefinitely.

The fresh air must not only be supplied to a space, but it must also be diffused equably throughout the space, so as not to pass directly from the point of entrance to the point of exit. It is very difficult practically to attain this end, but unless it is attained we fail to secure the proper displacement and renewal of the vitiated air.

Ventilation is effected either by natural means or by the aid of mechanical contrivances. The former is called natural ventilation and the latter artificial ventilation.

Natural Ventilation.—In all buildings there is an interchange between the inside and outside air by diffusion through the substance of the walls and floors themselves, but this interchange is insufficient to replenish the contained air, and provision must be made to supply the necessary amount of fresh air through openings in the walls, as doors, windows, etc., or through special openings into ventilating shafts; the latter method being the preferable one, especially for large assembly-halls and school-rooms.

The forces which are continually acting in nature and produce natural ventilation are diffusion, the action of the wind, and the difference in density of masses of air of different temperatures; the latter being the most important.

Diffusion.—All gases, including the mixture of oxygen and nitrogen which constitutes atmospheric air, diffuse through space, the force of the diffusion being inversely as the square roots of the densities of the gases. The diffusion of carbon dioxid, and the other gaseous impurities in the air of an enclosed space, into the fresh air takes place not only through the natural openings of rooms, as doors, etc., but also through the walls, floor, and ceiling, because the materials of which these are constructed are always more or less porous and permeable. The amount of ventilation through walls varies with the porosity of the materials of which they are formed; the temperature of the inside and outside air; the force and direction of the wind, etc. Damp walls are less porous than dry walls, and this is partly the cause of the unhealthfulness of damp houses.

The Action of the Wind.—This is exerted in two ways: (1) By perflation—that is, blowing through an air space and thus changing the air contained therein; and (2) by aspiration—that is, sucking up masses of air in consequence of a partial vacuum that is produced on either side of a moving mass of air. Perflation takes place through doors and windows, as well as through walls and ceilings. In the wards of a hospital, where thorough ventilation is of especial importance, the windows should be placed on both sides of the room, so as to allow full sway to the perflating action of the wind. Aspiration is provided when the wind blows over the top of a chimney or ventilating shaft and causes an upward current at right angles to its course. A strong wind may impede the movement of the air up the chimney. Down draught may be produced and smoke forced into the rooms.

Difference in Temperature.—The movement produced by the difference in weight of masses of air of different temperatures is the chief force acting in natural ventilation. When a mass of air is heated it expands, and proportionate volumes of it become lighter; consequently it rises to a higher plane and is displaced by colder and

heavier air. The greater the difference in the temperature of masses of air the more rapid the movement that is produced. The rate of movement may be calculated according to either of the following rules:

1. The velocity of falling bodies is equal to the square root of the space or height through which they have fallen, multiplied by the square root of twice the accelerating force of gravity. $V = \sqrt{2gs}$.

2. Rule of Montgolfier: Fluids pass through an orifice in a partition with a velocity equal to that which a body would acquire in falling through a space or height equal to the difference in depth of the fluids on the two sides of the partition.

All gases under constant pressure expand equally. If $V =$ the volume at 0° C., then the volume at $t° = V \times (1 + a \cdot t)$, where $a = 0.003665$. The effect of heat on air, therefore, is to increase its volume and to lessen its density directly in proportion to the increase in temperature.

Arrangements in Natural Ventilation.—In cold and temperate climates the openings that are usually present in inhabited rooms are doors and windows. Chimneys are also generally present. Ventilation is not the primary object of these openings, but nevertheless they act as ventilators, and in very many instances they afford the only means for ventilation. Diffusion takes place through all these openings, as well as through the walls, floors, and ceilings, and generally no special arrangements are needed to assist it in ordinary dwellings.

The natural ventilation through the pores of the walls is of slight significance. It occurs constantly in a vertical direction through the floor and ceiling. In winter, when the house is heated, it occurs from below upward, and in summer in the opposite direction, because the house is colder than the outside air. Along the side walls the excess of pressure diminishes from the floor to the ceiling, between which points there is a neutral zone where it is zero. In winter, in consequence of warming the room air, there is an outward movement above this zone,

and below it an inward movement of cold outside air (see Fig. 6); the reverse takes place when the room is colder than the outside air (see Fig. 7).

The perflating action of the wind must be utilized and regulated. Open doors and windows allow the entrance

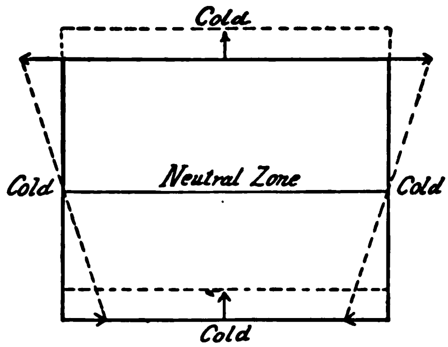


FIG. 6.

of moving masses of air, but if the movement is of sufficient rapidity to produce perceptible currents the doors and windows will probably be closed and the perflating

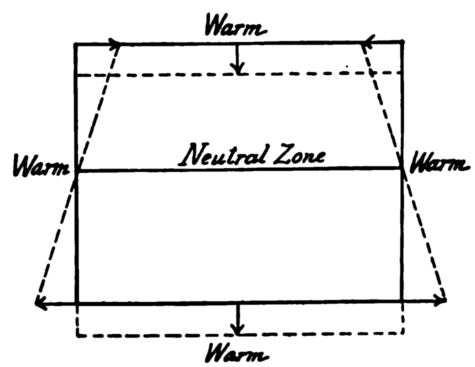


FIG. 7.

action of the wind arrested. The windows should always be placed on opposite sides of a room to secure free perflation and thorough change of the air. Even if this can be secured only at intervals, it is of special importance in the ventilation of wards of hospitals and of school-rooms.

If, however, some arrangement is made by which fresh air may be brought into a room without having the current impinging directly upon the occupants, the air of the room can be renewed, to a great extent, through the force of the wind. A simple plan by which this can be accomplished is to have the upper sash incline inward, leaving a space at the top through which air may enter, so as to direct the current of air upward toward the ceiling, where it is distributed to all parts of the room and slowly falls and displaces the contained air. Another plan is to place a narrow board beneath the lower sash, so as to raise its upper edge above the level of the bottom of the upper sash and form an opening between the two sashes, through which the air may enter (Fig. 8). By this arrangement the entering current of air is also deflected upward toward the ceiling. The same results may also be obtained by placing a louver near the top of the upper sash; or by placing a movable glass disk, perforated with holes, over one of the panes, which is perforated in a similar manner, when by rotating the disk communication can be made with the outside air whenever desired.

FIG. 8.—Window ventilator.

Inlet openings in the walls to utilize the perflating action of the wind may be either direct openings through the walls by using "air bricks," or valved openings, as the Sherringham valve, in which, instead of the air brick, an iron frame, containing a movable plate or valve on its inner surface, is inserted into the opening. When the valve is open, it directs the current of air upward toward the ceiling. It is easily

closed by reason of a well-adjusted counterbalanced weight. These latter arrangements are frequently employed in connection with what is known as the direct-indirect system of heating (Fig. 9).

Perflation may be aided by cowls attached to the tops of ventilating shafts. The cowls are composed of two tubes, one within the other, having a hooded cover with one large opening, at right angles to the mouth of the shaft, which is turned toward the point from which the

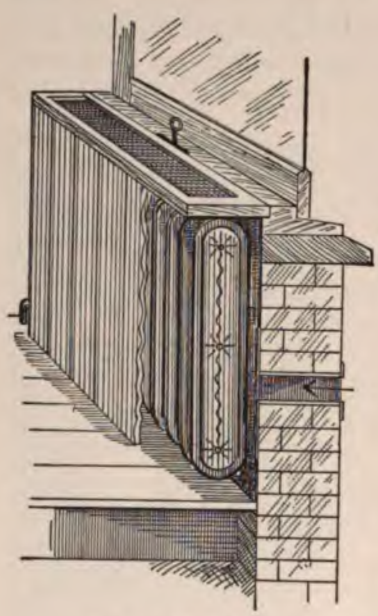


FIG. 9.—Wall air inlet.

FIG. 10.—Cowl.

wind is coming and directs its current downward through one of the tubes. They may be either movable or fixed; the latter being the preferable form, because it is less liable to get out of order. The best form of cowl consists of a fixed downcast tube with expanded, trumpet-shaped mouth, above which is a conical cap, the apex of which is turned upward (Fig. 10). With this arrange-

ment the aspirating force of the wind may be utilized to maintain a fairly constant current of air.

The movement produced by the unequal weights of masses of air of different temperatures takes place through

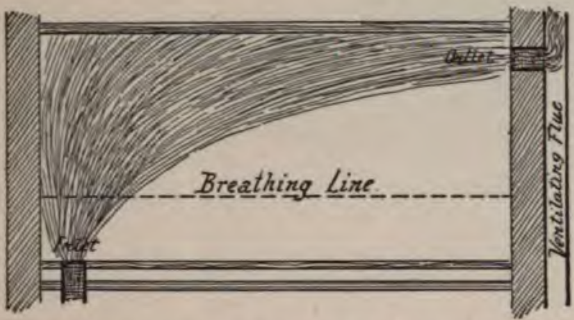


FIG. 11.—Air introduced at bottom, discharged at top.

the ordinary openings, and to some extent through the porous walls of a room; but, as the doors and windows may be closed and the movement be largely arrested, other openings should be provided to secure ventilation. The problem to be solved is—Which is the most satisfactory

FIG. 12.—Air introduced on side, discharged at top.

location for an outlet through which the vitiated air of an enclosed space may readily escape, and an inlet through which the fresh outside air may enter without causing a perceptible draught? The expired air of human beings is warmed to within about one degree of centigrade of the body temperature, and consequently it rises into

the upper part of the enclosed space. The air surrounding the bodies of the occupants is also warmed to some extent, and rises into the upper part of the space. These facts indicate that the proper place for the outlet openings

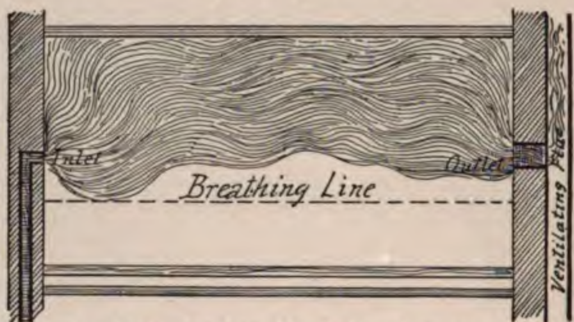


FIG. 13.—Air introduced on side, discharged on opposite side.

is in or near the ceiling. If artificial lighting is used, the air is heated as the result of the combustion and rises into the upper part of the space. This fact also indicates that the outlet openings should be placed in or near the ceiling, so as to allow air vitiated in this manner to

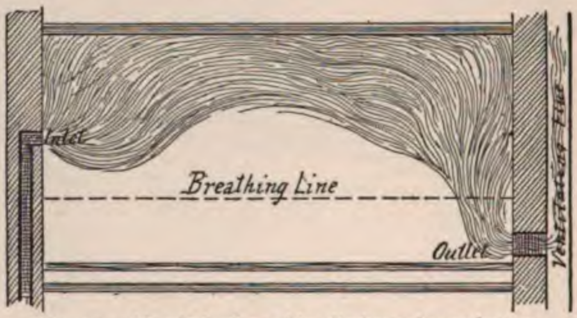


FIG. 14.—Air admitted on side, discharged near bottom.

escape as freely as possible, and to prevent it from mingling with the air that is to be respired.

With the outlet openings at the top of the enclosed space, the inlet openings should be at a lower level, preferably as near the floor as possible, in order to secure the greatest advantage possible from differences in density of

masses of air, by making the height of the column of heated air as great as possible. A current of cold air introduced at the level of the feet of the occupants would be unbearable, and various plans have been devised to

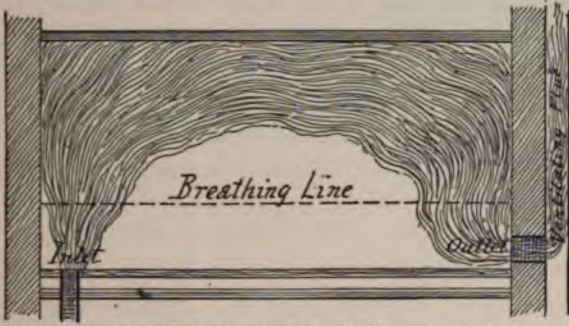


FIG. 15.—Air admitted at bottom, discharged near bottom.

obviate this difficulty, but in practice none of them has proved entirely satisfactory.

Some experiments were made by Mr. Warren R. Briggs, of Bridgeport, Conn.,[1] on the subject of the proper method of introducing pure air into rooms, and the best location for the inlet and outlet. The experiments were

FIG. 16.—Inlet near top, discharge near bottom.

conducted with a model having about one-sixth the capacity of a school-room to which the perfected system was to be applied. The movements of the air in the model of the building were made visible by mingling

[1] Carpenter's *Heating and Ventilation of Buildings*, p. 49.

smoke with the inflowing air-stream, which made the movements of the air visible.

The results of the experiments are shown graphically in Figs. 11 to 16. In each case the distribution of the fresh air is indicated by the curved lines of shading. A study of these sketches is very suggestive, as it indicates the best results when the inlet is on the side near the top, and the outlet is at the bottom and near the center of the room. The tendency of the entering air to form direct currents, which in some instances tend to pass out without perfect diffusion, is well shown. This tendency is less as the velocity of the entering air is reduced, and we probably get nearly perfect diffusion in every case where the outlet is well below that of the inlet, provided the velocity of the entering air is low—less than 1.2 meters per second.

In order to prevent the formation of draughts in the ventilation of rooms, the movement of the incoming air must be slow and gentle, it must be agreeable in temperature, and its humidity must not be too great nor too low. The conditions which cause draught are (1) too great rapidity of current, (2) too low a temperature, (3) excessive or (4) insufficient humidity of the air.

With regard to the size of inlets and outlets, the conditions of temperature are so variable that it would be impossible to fix a size that would be universally applicable. As an average for the temperate zone, a size of 156 square centimeters per head for inlet, and the same for outlet, seems calculated to meet common conditions; but arrangement should be made for enabling this to be lessened in very cold weather, or if the influence of very strong winds is felt. Each opening should not be larger than 300 to 400 square centimeters. Air expands on being warmed, but it is unnecessary to have a larger outlet area than the inlet area; indeed, one of the best ways of preventing draught is to ensure greater facility for entrance than for exit of the air. The shape of the opening of the inlet or outlet tube that causes least friction is the

circular, inasmuch as the area is larger in proportion to the periphery than that of any other figure.

Friction.—Some degree of friction is inevitable, and a deduction of one-fourth should be made in every case on this account. In addition to this, a further loss of velocity arises from the following causes: Size of the opening, shape of the opening, length of the shaft, angles in the shaft, and the presence of dirt.

The velocity of the air-current is readily determined by means of an anemometer (Fig. 17). If we know the size of the ventilating shaft and the velocity of the air-

FIG. 17.—Portable anemometer.

current, we can readily ascertain the amount of fresh air supplied.

Artificial Ventilation.—By artificial ventilation is meant that form of ventilation in which movement of air is induced by artificial contrivances. These are, broadly, of two kinds: Heat and mechanical means, and either of these may be arranged for extraction of foul air or propulsion of fresh air, the former being sometimes called the vacuum, the latter the plenum system.

Heat.—In practice heat is employed usually to produce ventilation by extraction, not by propulsion. The more common application of heat in artificial ventilation is in the extraction of air from a room through the ordinary

open fireplaces and chimneys. This action depends on the principle already treated of under natural ventilation —that of expansion of masses of heated air causing the production of upward currents.

The rate of flow up an ordinary chimney varies from 1 to 2 meters per second. Taking the ordinary size of a flue as 24 by 36 centimeters, it is seen that the discharge varies between 310 and 620 cubic meters, a quantity sufficient for 3 to 6 persons. The movement of the air will be toward the fire from all the openings in the room, which, if the fire burn briskly, are converted into inlet openings. The larger the fireplace and the fire, the greater the extractive force.

A heated column of air may also be produced by placing coils of hot-water pipes or steam pipes or gas-burners in a ventilating shaft. Whatever be the source of heat, it is best to place it at the bottom of the shaft, and not at the top. In places where a central lighting arrangement is adopted, as in the auditorium of theaters, advantage may be taken of the heat given off by the illuminating agent to carry off the impure air through a shaft placed above the chandelier.

The great disadvantage of extraction by heat is its irregularity of action. It is almost impossible to regulate the temperature of the column of heated air, consequently the upward current will sometimes be far more rapid than at other times. It is also costly on a large scale. Nevertheless, the ventilating power of the common open fireplace is so great that it is a most valuable method of ventilation.

Mechanical Aids.—These are chiefly fans, pumps, and jets. *Fans* are almost always rotary, and may be either centrifugal or axial (Fig. 18). The efficiency of a fan is estimated in terms of the volume, velocity, and pressure of the induced air-current compared with the horse-power required to produce it. Axial fans are more suitable where a large volume at low pressure and velocity is required; centrifugal fans, for the production of high velocity and high pressure. A large fan operated at low

speed is more economical than a small one at high speed. The blades are best curved in centrifugal, flat and inclined in axial, fans. Fans can be used either for extraction or propulsion; they may be operated by steam, wind, water, or electricity. The amount of air delivered by a centrifugal fan can be calculated by taking the velocity of revolution of the periphery of the fan; three-fourths of this equals the velocity of the air, this allowance being

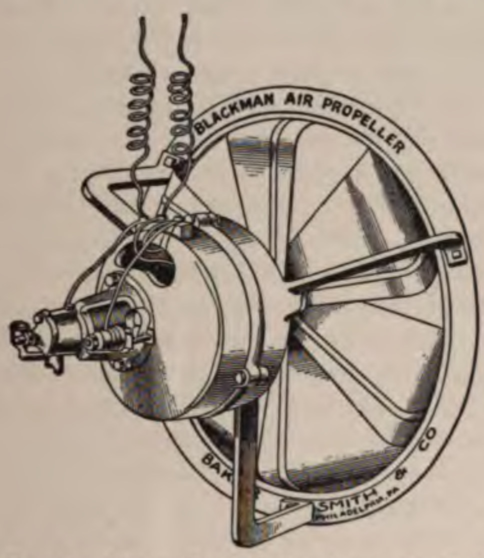


FIG. 18.—Air propeller, with electric motor attached.

necessary on account of friction. The sectional area of the conduit being known, the delivery per second can be calculated from these data.

Pumps are employed in the ventilation of mines, and may be used either for forcing in fresh air or extracting foul air. They are seldom employed in the ventilation of buildings.

Jets for producing currents of air are of three kinds—steam, compressed air, and water. Their efficiency depends principally upon the degree of pressure at which the jets issue from the nozzle. All jets are apt to be noisy, compressed air being least so. They can be used

either for extraction or propulsion; in the latter case the steam jet will moisten the incoming air considerably, which may be either an advantage or the reverse.

Arrangements for Artificial Ventilation.—There are certain points that require attention in all arrangements for artificial ventilation:

(1) The point of intake for the fresh air should be selected principally for the purity of the air obtained, and, as a general rule, the purest air will be found at a height of 3 to 4.5 meters (10 to 15 feet) from the ground.

(2) The air may require cleansing or filtering. With this object in view it may be made to impinge on a sheet of still water or, better, a film of glycerin, which retains impurities better and does not evaporate so readily. The air may be filtered through coarse cloth or cotton, the latter being most effective, but requires frequent renewal. A thickness of about 1.4 decimeters (6 inches) may be employed. The air may also be purified by washing it with a spray of water or passing it through a wire screen over which a fine stream of water is running. This adds moisture to the air and may require supervision, as hot, moist air produces languor.

(3) The temperature of the incoming air should be regulated. It may be cooled in summer by passing over ice, or, if the water spray is used, this may be cooled by ice, which is an effective method of reducing the temperature. An apparatus devised by Professor Gates, of Washington, for the cooling of rooms in summer, can be more cheaply operated than a coal stove in winter. It is simply a tall cylinder of galvanized iron resting in a large basin or pan, and connecting at the top with the ordinary stove pipe or with a tube leading out of a window. In the top of the cylinder's interior is a perforated tubular ring, and on a cock being turned on this ring an artificial shower is produced inside the cylinder. The water thus flowing down the sides takes on a rapid spiral motion which sucks the air down the cylinder at a rapid rate; the fine spray inside cooling the air, reducing its humidity to normal, and purifying it of all dust and odor.

The water collects in a basin below, from which it is drained off, the cool air escaping through openings just above the water surface of the basin. In some experiments made with this apparatus the temperature of the air on entering the cooling cylinder was observed to be 33° C., while it was 20° C. on taking its exit at the bottom. Recently "liquid air" has been introduced as a means of cooling the air, and has been applied with satisfaction in the ventilation of theaters.

The incoming air may be warmed by passing over or through a heating apparatus, such as hot-water or steam pipes. This is the method now commonly employed in the ventilation of large buildings. The whole of the air-supply, in a scheme of artificial ventilation, ought to be admitted at the required temperature to the chamber to be ventilated, and no attempt should be made to warm the room by superheated air. As a rule, the fresh air should be warmed as near as possible to the temperature desired in the room. In large buildings, consisting of many rooms, the scheme of ventilation requires separate and perhaps different arrangements in different portions. In other buildings, such as churches and theaters, a single central scheme is preferable.

(4) The channels through which the air is conducted should be so arranged as to be easily cleansed; this is especially necessary in propulsion methods, and inattention to this point has in many instances brought the method into disrepute. Where the air has been previously filtered there will, of course, be less deposit of dust on the sides of the inlet shafts. Extraction shafts also require to be kept clean.

The inlet and outlet openings must be so placed that a thorough aëration of the room is possible without the production of draughts. Different arrangements are required for the inlet and outlet openings for winter and summer. In summer the cool air is brought in at a height of from 2 to 3 meters above the floor in such a manner that it is conducted toward the ceiling. From this point it sinks gradually, and when warmed rises and

takes its exit at the opposite side of the room near the ceiling. In winter the air takes its exit near the floor.

The system of ventilation should be so constructed that it can be regulated to meet all reasonable requirements as to quantity of air furnished and the temperature that may be demanded by atmospheric conditions.

Removal of Dust.—The removal of dust in factories requires special arrangements. The circulation of air in

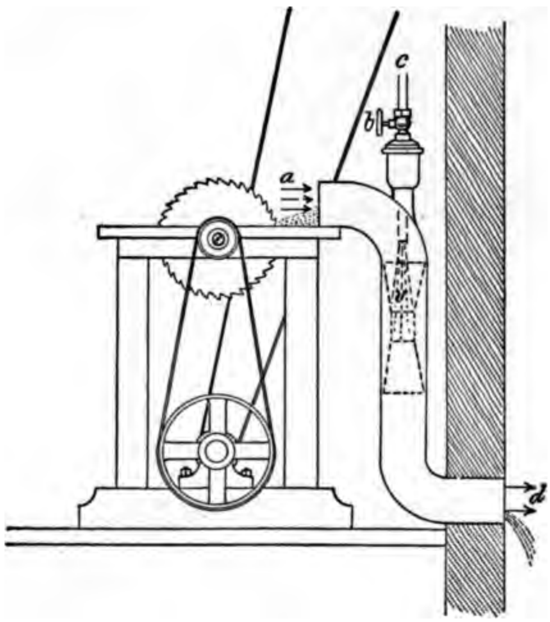


FIG. 19.—Apparatus for removing dust in manufacturing establishments: *a*, inlet to exhaust shaft; *b*, valve regulating spray; *c*, water-supply pipe; *d*, outlet of exhaust shaft.

closed rooms is insufficient to keep the dust from settling, and, especially in factories, special arrangements for its removal are required. Where large quantities of dust are produced, as in certain factories, it is often possible to apply a strong air current near the source of the dust in order to aspirate it, as in the case of circular saws and grindstones (Figs. 19, 20, 21). Where the dust cannot be satisfactorily removed by such a method it is often

possible to modify the manufacturing process so as to prevent excessive dust formation. The use of a spray of water so as to render the material damp and thus prevent,

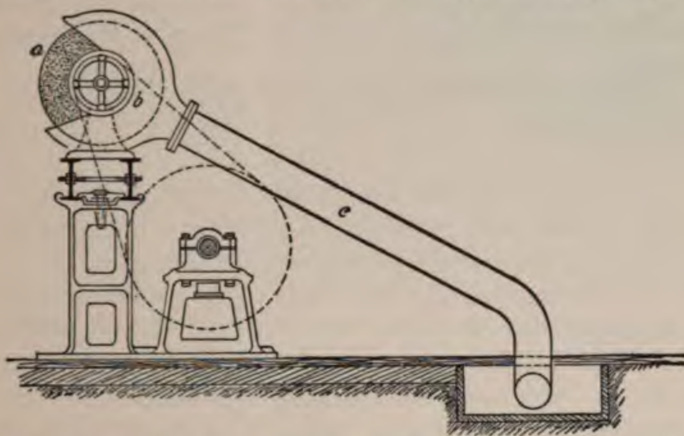


FIG. 20.—Apparatus for removing dust in manufacturing establishments: *a*, emery wheel; *b*, hood over emery wheel; *c*, exhaust shaft.

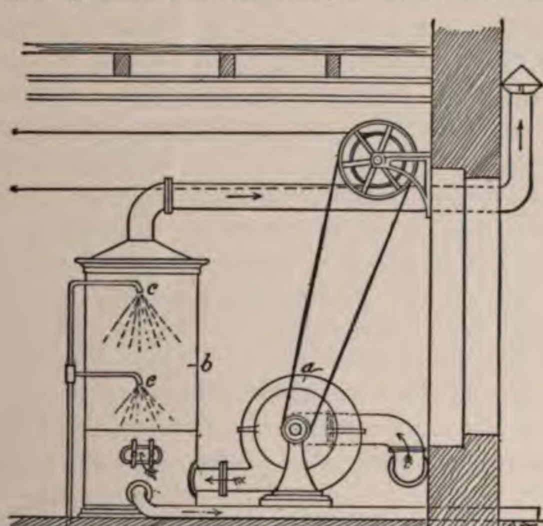


FIG. 21.—Apparatus for removing dust in manufacturing establishments: *a*, blower; *b*, dust-collecting chamber; *c*, water-sprays.

in large part, the formation of dust will aid in keeping the air pure.

In houses and hospitals dust is to be prevented as much as possible. If dust has formed, it tends to settle upon horizontal surfaces, and should be removed with damp cloths.

Comparison of Extraction and Propulsion Methods.—The extraction method is less costly and utilizes the naturally high temperature of the vitiated air. Its disadvantages are that the source of the incoming air is not under control, and, consequently, impure air may be admitted and there is greater liability to draught. In the propulsion method the inlets are entirely under control if properly arranged, and the purity of the air can be assured, as well as its suitable temperature and velocity, so as to avoid draughts. A proper diffusion of the incoming air throughout the room is more easily effected in the propulsion than in the extraction method. The disadvantage of propulsion is its greater cost. A combination of the two methods is frequently employed, and meets all the requirements.

Comparison of Natural and Artificial Methods.—(1) Natural ventilation is rarely sufficient, and usually requires to be supplemented. (2) For dwellings, extraction by heat by means of open fireplaces and chimneys is generally sufficient. It is automatic and requires no special attention, but it is not a perfect system of ventilation. (3) For large halls, churches, theaters, and schools artificial ventilation is necessary. In buildings of this character mechanical methods have a decided advantage over natural ventilation, not only in the greater purity of the air, but in the more equable temperature attainable.

Humidifying the Air.—The air of houses is frequently very dry during the colder months of the year owing to the reduction of the relative humidity of the air simply by raising its temperature and thus raising its ability to take up moisture. If the temperature of the outside air is 0° C. and its relative humidity

100 per cent., the fact that the air is warmed to 20° C. while passing through the heating plant causes the relative humidity to fall to 38 per cent., since air at 0° C. when saturated holds 4.90 gm. of water per kilogram, while at 20° C. it could hold 12.74 gm.

In order to increase the relative humidity of the air in heated houses various plans have been suggested to add moisture to the air. In furnace-heated houses a shallow pan of water is placed in the bottom of the heater, but this is not very effective because only a part of the air to be warmed passes near the pan before it is warmed, and hence the amount of moisture taken up is more or less limited; another device to add moisture to the air of furnace-heated houses consists in placing a shallow pan at each register opening so that the incoming air may take up moisture. This plan is more efficacious than the former.

In houses heated by steam it has been suggested that the humidity of the air may be increased by allowing a small amount of steam to escape from each radiator. This method is objectionable because of the slight noise from escaping steam; the possibility of some of the condensed steam dropping to the floor, and the difficulty of supplying an appropriate amount of moisture. In large buildings equipped with appropriate appliances for heating the air is propelled through the heating plant by large fans, and this gives an opportunity for adding moisture since the air may be forced through screens over which a fine stream of water is falling. This method is quite satisfactory.

Temperature and Humidity Conditions of Air.[1]

	Fahrenheit.	*Relative Humidity.*
Normal	68 degrees.	50 per cent.
Cold	50 degrees.	50 per cent.
Hot dry	80 degrees.	20 to 30 per cent.
Hot medium	80 to 86 degrees.	50 per cent.
Hot moist	80 to 86 degrees.	80 per cent.

[1] Miller and Cocks, Trans. Amer. Climatological Association, 1915.

CHAPTER III.

HEATING.

HEATING must always be considered in connection with ventilation. This is necessary for several reasons. The combustion of coal utilizes oxygen, and as a result the products of combustion are given off. In order to supply air for combustion and draught fresh air must be introduced. It is also necessary to have a supply of fresh air to replace the heated air which escapes from the building.

Loss of Heat from Buildings.—Heat is required to warm the air of a room to a given temperature, to supply the loss of the heat from radiation and conduction from the windows and walls, and to supply the heat for the air required for ventilation. The amount of heat required for these various purposes will depend largely upon the construction of the building, the amount needed for purposes of ventilation, and the difference between the inside and outside temperature. The loss of heat from the walls of buildings depends upon the material used, its thickness, the number of layers, the difference between the temperature of outside and inside surfaces, and the air exposure. For ordinary temperatures and pressures about 1 cubic meter of air will absorb 1 calorie in being warmed 1 degree C., and hence can be considered the equivalent of 1 kilogram of water. The number of calories required for ventilation can then be found by multiplying the number of cubic meters of air by the difference between the inside and outside temperature, and this product by the number of times the air is changed in an hour.

Degree of Warmth.—The temperature most suitable

for healthy persons ranges from 17° to 20° C. for living rooms, and 15° to 18° C. for bed-rooms. For children and aged persons a somewhat higher temperature is required. No standard temperature can be named, because a temperature just comfortable for one person may be too warm or too cold for others. Custom and occupation have a great influence in deciding the matter.

Heat Supplied by Radiating Surfaces.— The heat used in warming is obtained either by directly placing a

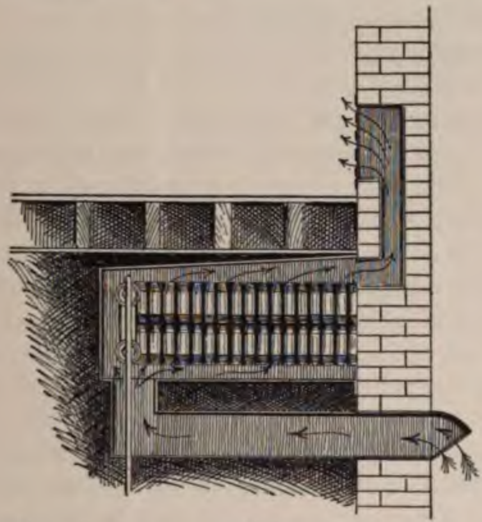


FIG. 22.—Arrangement of indirect heating surface.

heated surface in the apartment, in which case the warmth is said to be obtained by direct heating, or else by warming the air used for ventilating purposes while it is passing to the room, in which case the heating is said to be by indirect heating (Fig. 22).

Direct heating is performed by locating the heated surface directly in the room, and this surface may be heated directly by fire, as is the case with stoves and fireplaces, or it may receive its heat from steam or hot water warmed in some other portion of the premises and conveyed in pipes. The general principles of heating are the same in each case, but in the case of stoves the tem-

perature is greatly in excess of that derived from steam or hot-water radiators. The heat is carried away from the heated surface partly by radiation, in which case the heat passes in straight lines in all directions and is absorbed by the bodies of persons, by the furniture and walls of the room, without warming the intervening air directly. The heat is also carried away by particles of air coming in contact with the heated surface—that is, by convection—which may be the radiating surface, the bodies of persons, or the furniture and walls of the room which have been warmed by the radiant heat.

The sensations produced by radiant and convected heat are quite different. Radiant heat has the effect of intensely heating on the side toward the source of heat, and producing no warming effect whatever on the opposite side. The heat which has passed off by convection is first utilized in warming the air, and the sensation produced is that of heat equably distributed. Radiant heat and convected heat are essentially of the same nature; in the one case it is derived directly from the source of heat, and at a high temperature; in the other case it is received from the air, which is at a comparatively low temperature.

Resistance to Radiation.—The heat in passing through any metallic substance raises its temperature to an extent which depends upon the facility with which heat is conducted by the body and discharged from the other surface. It is noted that heat meets with three distinct classes of resistance in passing through a metallic substance: First, that due to the inner surface; second, that due to the thickness of the material; and third, that due to the outer surface. The first and third resistances are due to change in media, and, when the material under consideration is a good conductor, constitute the principal portion of the resistance to the passage of the heat.

Heat Emitted by Radiation.—Heat emitted by radiation, per unit of surface and unit of time, is independent of the form and extent of the heated body, provided there are no re-entrant surfaces which intercept rays of radiant

heat. The amount of heat projected from a surface of such form as to radiate heat equally in all directions depends only on the nature of the surface, the excess of its temperature over that of the surrounding air, and the absolute value of its temperature. The rate of cooling due to radiation is the same for all bodies, but its absolute value varies with the nature of the surface. The construction of the ordinary form of radiator is such as to present very little free radiating surface, as all the heat which radiates from one tube to another is reflected or reabsorbed, and is consequently not used in heating the apartment. The greater portion of the heat removed is, no doubt, absorbed by the air which comes in contact with the surface, or by convection. The heat removed by convection is independent of the nature of the surface of the heated body and the surrounding absolute temperature. It depends on the velocity of the moving air, and is thought to vary with the square root of the velocity. It also depends on the form and dimensions of the heated body, and on the excess of its temperature over that of the surrounding air.

Systems of Heating.—There are three systems of heating in common use:

(1) *Direct*, where the heating surface is in the room, as a stove, steam coil, or open fireplace. The heat rays from an open fireplace are radiant. They do not warm the air directly. Heat from a moderately hot stove or from a steam coil is very little radiant. The particles of air are heated and brought into circulation—heating by convection. This is the cheapest, though probably the least satisfactory, method of heating.

(2) *Indirect*, where the heating surface is not in the room heated, but in some other portion of the premises, such as a furnace in the cellar. It is impossible to heat by the indirect method without bringing more or less air into the room. It necessitates some ventilation. It is always more costly than the direct method, but is usually more satisfactory and less troublesome.

(3) *Direct-indirect*, where the heating surface is in the

room, but has air coming from the outside at the same time (usually so arranged that the supply of outside air can be cut off, converting it into direct heating). Direct-indirect heating is, theoretically, a desirable method of heating and ventilation because it permits the introduction of large quantities of fresh air. The method is objectionable for two reasons—it is responsible for the introduction of considerable quantities of dust, and it is expensive because of the large amounts of air that are brought in through the radiator.

Direct Heating.—Open Fireplaces.—With open fireplaces the heating is almost entirely by radiation, as there is very little opportunity for convection of heat. Its advantages are limited, though important. It adds little of the impurities of combustion to the air of a room, and it ensures the extraction of considerable amounts of the room air. The objections to this mode of heating are that a very large proportion of the heat is lost, and the portion utilized is only given off as radiant heat, thus warming only one side of the body, while the opposite side remains cold. It is also productive of cold draughts, because the cold outside air always tends to flow directly toward the fireplace. The heating is inconstant on account of changes in the direction of the wind. This method of heating is of greatest importance as an adjunct to other systems, such as the heating of the wards of a hospital where an open fireplace is quite cheerful, when the system of heating is by means of hot air or by steam.

Stoves.—The principal advantages of stoves are that a considerable amount of the heat generated is utilized, and the heating is under more direct control and supervision. The disadvantages of this method of heating are that there is a tendency for the air to become dry, and there is no ready means for introducing fresh air. It is objectionable because of the large amount of dust which is produced.

Steam and Hot-water Radiators.—The use of steam and hot-water radiators involves the installation of a general heating system of which the radiators are only a

small part. As far as efficiency of heating is concerned, there is very little to choose between these two methods. The hot-water system is more expensive to install, but the running expenses are lower than for steam, because it is less expensive to warm the water to 100° C. than to convert it into steam at 100° C. Moreover, in hot-water heating the water is never heated to the boiling-point, hence much less fuel is required.

Heating by Steam.—When water is converted into steam 537 calories are absorbed or rendered latent; 1 kilogram of water at 100° C. requires as much heat to convert it into steam at 100° C. as would raise 537 kilograms 1 degree C., or 1 kilogram 537 degrees C. This is termed the latent heat of steam, and in condensing back into water this heat is given off and can be utilized for purposes of heating.

Steam-heating plants are either high or low pressure. High-pressure systems are now generally called expansive systems. They carry steam at a pressure of over 700 grams to the square centimeter, while the low-pressure systems carry steam at less than 700 grams, usually from 150 to 350 grams to the square centimeter. The low-pressure systems are now principally used.

Systems of Piping.—There are three systems of piping in use: (1) The two-pipe system, which is most commonly employed, and can be used for either high- or low-pressure steam. The main return riser is carried below the water-line of the boiler. Various modifications of this system are in use. Each radiator is provided with separate flow and return pipes. (2) A partial-circuit system, in which the main flow pipe rises to the highest part of the basement by one or more branches, whence the distributing pipes run at a slight incline, and finally connect with the boiler below the water-line. The radiators are connected by risers which carry both flow and return from and to the distributing pipes. The pipes must be made large. This system is employed quite extensively in private houses. (3) The complete-circuit system, often called the one-pipe system, in which

the main pipe is led directly to the highest part of the building; thence distributing pipes are run to the various return risers, which in turn connect with the radiating surface and discharge in the main return. The supply for the radiating surface is all taken from the return risers, and in some cases the entire downward circulation passes through the radiating system.

Exhaust-steam Heating.—This does not imply any particular method of running the pipes, but proper connections must be made between the exhaust and the heating pipes, and provision must be made for taking care of the condensed water.

Hot-water Heating.—On account of its high specific heat water is able to store heat, which it, on cooling, gives up. One kilogram of water in cooling from 100° C. to 20° C. gives up 80 calories, which can heat $8 \times 4 = 32$ kilograms of air through 10° C., because the specific heat of air is only one-fourth that of water. Thirty-two kilograms of air are equal to 24.61 cubic meters.

Methods of Piping.—A system of hot-water heating should present a perfect system of circulation from the heater to the radiating surface, and then back to the heater. An expansion tank, on the top floor, must be provided to prevent excessive pressure due to the heating and consequent expansion of the water. In the system ordinarily employed for hot-water heating the mains and distributing pipes have an inclination upward from the heater, while the returns are parallel to the main and have an inclination downward toward the heater, connecting at its lowest part. In this system great care must be taken to produce nearly equal resistance to flow in all the branches leading to the different radiators. It will be found that invariably the principal current of heated water will be in the path of least resistance, and that a small obstruction, as any irregularity in the piping, is sufficient to make very great differences in the amount of heat received in different parts of the same system.

The expansion tank must in every case be connected to a line of piping which cannot by any possibility be

shut off from the boiler. It does not seem to matter whether it is connected with the main flow or with the return.

Combination Systems of Heating.—Several methods have been devised for using the same system of piping alternately for steam or hot water, as the demand for higher or lower temperature might change.

Indirect Heating.—By Means of Steam Radiators.—Radiators which are placed in a passage or flue which supplies air to a room supply heat by the indirect method. These heaters are made in various forms. They should be placed in a chamber or box as nearly as possible at the foot of a vertical flue leading to the room to be heated. Air is admitted through a passage from the outside provided with suitable dampers. The chamber surrounding the radiator and the flue leading from the chamber are constructed of masonry or of galvanized iron, and that supplying the cold air of wood lined with tin. There should be a door into the chamber, so that the heater may be cleaned when necessary. It is of great advantage to have a by-pass and mixing dampers in the flues, so that the heated air can be mixed with cold air in order to attain the desired temperature of the incoming air. These dampers are often regulated automatically by means of thermoregulators, whereby the desired temperature is maintained by mixing requisite amounts of heated and cold air.

The system of indirect heating by means of steam radiators in stacks is now very generally in use for large buildings, and when a fan is used to propel the air through the building affords the most satisfactory system of ventilation and heating. When all the arrangements have been properly made the requisite amount of air can be forced into the building and at the desired temperature. In comparison with the efficiency of the ventilation and heating with this system the cost of the system is no great objection.

Heating with Hot Air.—The general laws which apply to hot-air heating have already been considered in con-

7

nection with ventilation and the indirect methods of heating. The outside air is conducted through an outer casing surrounding a furnace, and when heated rises through the flues and passes into the rooms above. The rapidity of the circulation depends entirely upon the heat of the furnace and the height of the flue through which it passes. In order that the circulation of air through the rooms may be more perfect, outlet openings must be provided for the escape of the impure air. This system is not adapted for large buildings, because the horizontal distance to which heated air will travel is somewhat limited. When properly proportioned, in buildings of moderate size, this system gives fairly satisfactory results.

In order that the hot-air system may be satisfactory in every respect, the furnace should be sufficiently large, and the ratio of heating surface to grate such that a large quantity of air may be heated to a low degree, rather than a small quantity to a high degree of temperature. The air-supply of the furnace is usually derived from the outside through a shaft specially constructed for this purpose, though in many private dwellings the air is drawn immediately from the basement. The disagreeable effects of the air of furnace-heated rooms are due to the dryness of the air. The principal objection to furnace-heating is the fact that when the supply of heat is shut off, the supply of fresh air is also excluded.

Heating with Electricity.—Electrical energy can be transformed into heat, and as there are certain advantages pertaining to its ready distribution, it is likely to come into more general use for heating. One watt for one hour, which is the ordinary commercial unit for electricity, is equal to 3.41 calories. Electricity is usually sold on the basis of 1000 watt-hours (1 kilowatt) as a unit of measurement, the watts being the product obtained by multiplying the amount of current estimated in ampères by the pressure or intensity estimated in volts; on this basis 1000 watt-hours are equivalent to 3410 calories. The expense of electric heating must in every

case be very great, unless electricity can be supplied at an exceedingly low price.

Heating by Means of Gas.—In many towns throughout the natural gas region gas is used for heating as well as for illuminating purposes. In these localities gas is the cheapest mode of heating. It is employed in both the direct and indirect systems of heating. When suitable arrangements are made for carrying off the products of combustion, and there is a proper supply of fresh air for purposes of ventilation, this is a very satisfactory method of heating. In cold weather, where the daily fluctuations in the temperature are not very great, the gas heater can be lighted and adjusted, and requires practically no attention for weeks or even months. It is therefore a great saving in time and annoyance, and there is no coal to shovel nor ashes to remove.

Heating by Means of Petroleum.—Within recent years petroleum has been brought into common use for heating purposes. The advantages of oil heaters are that they are portable and may be carried from one room to another, and the amount of heat can be readily controlled. These petroleum stoves are objectionable, however, from the fact that the combustion of the petroleum utilizes large quantities of the oxygen of the air of the room, giving off corresponding amounts of carbon dioxid. Babuke[1] has found that in a room of 12 cubic meters capacity, during the first hour the temperature was raised only 4 degrees C., and rose but slowly afterward. The proportion of carbon dioxid in the air exceeded 1 part per 1000, and reached in the vicinity of the floor 3–10 parts per 1000, and in the upper part of the room 6–12 parts per 1000, amounts which would be detrimental to health when inhaled constantly. The amount of petroleum consumed was about a liter in eight hours.

Heating with large petroleum heaters, by introducing a number of separate units into a hot-air heater, is now coming into use. When these heaters are properly constructed they are quite satisfactory.

[1] *Zeitschrift f. Hygiene*, Bd. xxxii., S. 33.

CHAPTER IV.

WATER AND WATER-SUPPLY.

Physical Properties of Water.—Pure water is a colorless, odorless, and tasteless liquid, of neutral reaction, and is taken as the type of all liquids, as air is the type of all gases.

Chemical Composition.—Pure water consists of 2 parts by weight of hydrogen and 16 parts by weight of oxygen, having a molecular weight of 18. Two volumes of hydrogen combine with 1 volume of oxygen to form 2 volumes of water gas, having a density of 9. The chemical formula for water is H_2O. The percentage composition of water is hydrogen, 11.11; oxygen, 88.89.

Chemically pure water does not exist in nature, but is made in the laboratory by mixing the required amounts of hydrogen and oxygen gas and then passing an electric current through the mixture. The gases unite and form water. From the hygienic standpoint, water as found in nature is either "pure" or "impure." Hygienically pure water is one which does not contain any foreign matter which is injurious to health. Impure water is one that is unfit for domestic use. Water as it exists in nature contains a great variety of substances derived from the air through which it has fallen as rain or snow, and from the soil over and through which it has passed. The nature and quantity of the mineral salts dissolved out of the soil by water are dependent upon the chemical composition of the soil. The nature and amount of organic matter contained in the water are dependent largely upon the nature of the soil-covering over which the water has passed.

Water as it occurs in nature may be divided into rain-water, spring-, ground-, river-, lake-, and sea-water. Each of these natural waters varies somewhat according to the locality from which it is derived, though in a general way all of these natural waters possess characteristics which are common to all the waters of that particular class.

Rain-water.—If rain-water were collected in a chemically clean vessel at the moment when it was condensed, it would presumably be chemically pure, but in falling through the atmosphere it takes up some of the impurities in the air. Rain-water is one of the purest of the natural waters, but it varies in purity with the nature of the atmosphere through which it has fallen. It is always purer at the end than at the beginning of a shower. It contains dissolved gases derived from the atmosphere—on an average 25 cubic centimeters per liter, of which about 64 per cent. is nitrogen, 34 per cent. oxygen, and 2 per cent. carbon dioxid. The relatively large amount of carbon dioxid, in comparison with the proportion contained in atmospheric air, is due to its large absorption coefficient. Ammonia is also commonly present. The average amount of solid matter in rain-water is 39.5 parts per 1,000,000. Sodium chlorid is the most abundant salt, while nitric acid and nitrates, sulphuric acid and sulphates, and a little organic matter are also commonly present.

Spring-water.—That portion of the rain-water which penetrates the ground exercises a powerful chemical action on the substances present in the soil and underlying rocks. This action consists of solution, hydration, oxidation, etc. Rain-water is an oxidizing agent on account of the considerable proportion of dissolved oxygen that it contains.

Springs may be divided into two classes: Common springs, yielding fresh, potable water; and mineral springs, yielding mineral, thermal, or medicinal waters, in which the dissolved mineral matters render them unfit

for ordinary domestic use, though of great value for therapeutic purposes.

Ordinary spring-water usually contains the gases of the atmosphere in solution. It also contains various mineral salts in solution, such as calcium carbonate and sulphate, magnesium carbonate and chlorid, sodium chlorid, alkaline sulphates and nitrates, and silicates. The amount of organic matter is usually small, and the content in free and albuminoid ammonia is low. The temperature of spring-water is usually lower than that of the surrounding air.

Ground-water is the water which has fallen upon the surface as rain or snow and penetrated to varying depths of the earth's crust, and can be brought to the surface by deep borings or by the construction of collecting galleries at points where the water is carried along underground over impervious strata. The character of ground-water varies markedly in different localities and at different depths owing to the geologic strata through and over which it has passed. In many localities excellent drinking-water can be obtained, though the quantity may be somewhat limited, depending upon circumstances.

Well-water, if derived from a deep well, is similar in character to spring-water; but if derived from a shallow well it is contaminated with surface washings. Spring-water is usually soft, while some well-waters are moderately hard because of the presence of calcium and magnesium salts in the rocks of the locality. Spring- and well-waters are usually not rich in bacteria unless specially polluted.

River-water.—The course of a great river may be divided into three portions—the mountain track, the valley track, and the plain track; and the composition of the water varies considerably in these three portions of its course. In the first part it is comparatively pure and partakes of the nature of spring-water; in the second and third parts it is usually more or less polluted, depending upon the density of the population along its course. The composition of river-water is complex, as in the

case of spring-water, as the water of rivers is largely derived from springs. The proportion of organic matter and of free and albuminoid ammonia is usually higher than in spring-water; and if polluted with sewage the proportion of chlorin is also considerably higher. The character of the water varies greatly with the amount of rainfall and with the nature of the soil-covering of the valley and plain tracks. River-water is usually rich in bacteria, the number and variety of species varying greatly with the season of the year and the amount of sewage pollution.

No stream flowing through a thickly populated district is safe as a source of drinking-water supply because of the many points from which polluting materials may gain entrance. All water derived from streams should be purified in some effective way before it is supplied to the consumers.

Lake-water.—Lake-water is of variable composition, the water of salt lakes being loaded with mineral constituents, while that of fresh lakes is usually of great purity. Fresh-water lakes act as settling basins for the inflowing water. The sudden diminution in the velocity of the current causes the subsidence of suspended matters, while oxidation of organic matters takes place from exposure of so large a surface to the atmosphere, and from the action of microscopic plants and bacteria.

Sea-water.—Sea-water is appreciably alkaline from the presence of carbonates. The proportion of solids in solution is about 3.5 per cent.; chlorin being the chief constituent, while sodium, calcium, and magnesium are next in amounts. It also contains considerable amounts of atmospheric gases, even at great depths, the average amount being from 2 to 3 per cent. by volume.

Impurities in Water.—By the term impurities is meant such substances as are directly injurious to health, or that from their association are indicative of pollution though in themselves they may be harmless. The impurities in water may be either in suspension or solution,

and they may be either gaseous or solid, organic or inorganic.

Many of the inorganic constituents of water are injurious only when present in considerable amounts—as, for instance, the *salts of calcium* and *magnesium*. These, when present in large amounts, render the water hard and therefore unsuited for domestic use, aside from the fact that they are productive of disordered function of the gastro-intestinal apparatus. The amount of *sodium chlorid* commonly found in natural waters is not objectionable, because it is much smaller than the amounts constantly used in seasoning food. Sodium chlorid is, however, a most important indication of the pollution of surface-waters with sewage, since sewage is rich in chlorin derived from urine. In determining the significance of the amount of chlorin found in any water, it is necessary to know the normal chlorin content of the surface-waters of the locality, since the amount of chlorin normally present in surface-waters varies greatly. The amount is influenced by the proximity to the ocean or other bodies of saline water, by the proximity to natural deposits of salt, and by the geologic formation of the locality. The chlorin content of surface-waters of the natural gas and oil regions is especially high, and this fact must be borne in mind in determining the significance of chlorin present in water from such a locality. The amount of *nitrates* and *nitrites* commonly found in surface-waters is without influence upon health. These substances are, however, of great interest and importance as indications of the length of time that has elapsed since the water has been polluted and the extent of the pollution.

The *organic impurities* in water are of two kinds, dead organic matter of vegetable and animal origin, and living organisms. The amount of dead organic matter commonly found in surface-waters is without effect upon health. It serves, however, as a most important indicator of the extent and character of pollution. The organic matter present in water is usually divided into

the nitrogenous organic matter and the oxidizable organic matter. The nitrogenous organic matter usually represents animal organic matter, and is estimated in the form of free and albuminoid ammonia, though it is not always of animal origin, as certain vegetable compounds also yield ammonia on distillation, and, therefore, are nitrogenous in character. The oxidizable organic matter is usually of vegetable origin, and is determined by its bleaching effect upon a solution of potassium permanganate. Neither the nitrogenous organic matter nor the oxidizable organic matter is, as a rule, directly injurious to health, and these also are of importance principally as indicators of the nature and extent of pollution.

In making the estimates of the amounts of these various organic and inorganic impurities in water it is necessary to bear in mind that all waters contain certain amounts of these substances. It is only when the quantities of these substances found exceed to an appreciable extent the normal content of the surface-waters of the locality that they become indicators of pollution.

The *living organisms* found in water may be either of vegetable or animal origin. The vegetable organisms found in polluted water are of two kinds, the pathogenic and putrefactive bacteria, and those organisms which are of a somewhat higher organization—certain chlorophyl-bearing organisms.

The *bacteria* found in polluted water which are of the greatest importance are the various pathogenic organisms, the most important of which are the typhoid bacillus, the cholera organism, and Clostridium welchii. Bacillus coli is also of importance because it is normally present in the intestinal discharges of man and the domestic animals. But its discovery in any surface-water is not positive indication of sewage pollution, as it may have gained entrance from street-washings or from the fecal matter of any of the domestic animals. Its presence in water is cause, however, for suspicion because it shows that the water is not properly protected against pollution.

The presence of Clostridium welchii is believed by some to indicate sewage pollution to an equal extent with the presence of the colon bacillus. It is regarded as a frequent factor in the production of diarrheal diseases, especially in infants. There are also a number of common putrefactive bacteria which are not normally present in pure surface-waters, and the presence of which is, to some extent at least, indicative of pollution. This is believed to be true of such organisms as those of the *proteus group* and the *lactic-acid group*, and the organisms may be instrumental in producing gastro-intestinal disturbances when present in water in large numbers. The various pyogenic cocci may also occasionally be found in polluted waters, and their presence in drinking-waters is objectionable. A streptococcus has been discovered in polluted waters by Houston and is known as the sewage streptococcus of Houston. This organism is believed by many investigators to indicate sewage contamination just as positively as does the presence of the colon bacillus.

Bacteria are present to a greater or less extent in all natural waters. Many species have their normal habitat in water and in the soil, through which they gain entrance to surface-waters. The point of hygienic importance is, therefore, not whether bacteria are present or absent, because they are practically never absent; not whether they are few or many in number, because no direct relation has been proved to exist between their number and the purity or impurity of the water, though, as a rule, the larger the number present the greater the amount of food-supply for bacteria in such water, and hence the better facility for growth and development of all species; nor even how many different species are present. The point of real hygienic importance is to determine whether the water does or does not contain any of the organisms of specific diseases. Since the detection of the typhoid bacillus in suspected waters, by the methods known at the present time, is tedious and difficult, the bacteriologist is obliged to base his opin-

ion as to the purity of a water upon the associated species present, as well as upon the relative number of bacteria in the water. It is inferred that a water rich in bacteria contains the necessary food-supply for the growth and development of bacteria, and hence it would support the life of any pathogenic species that might gain access thereto, therefore a high bacterial content is looked upon as indicating possible contamination with sewage. If, in addition to this, the water contains well-known sewage bacteria, as Bacterium coli, Proteus vulgaris, Clostridium welchii, and the sewage streptococcus, it is regarded as being polluted with sewage.

Filtered water and spring water should not contain more than 50 colonies per cubic centimeter that are able to develop at body temperature on agar plates in forty-eight hours. Even greater numbers of colonies are permissible provided the water does not contain members of the colon group of bacteria. A safe standard for drinking-water is less than 2 colon bacilli per 100 c.c. of water.

The *chlorophyl-bearing organisms* found in surface-waters are, as a rule, harmless, but certain species when present in reservoir-water give rise to disagreeable odors and taste, and hence are objectionable. These odors are usually produced by the growth of algæ, or diatoms. The principal algæ which have been found to produce these disagreeable odors in stored water are different varieties of volvox, uroglena, and anabena. The diatom asterionella has been found to cause a "geranium" odor and taste in stored water. Another pest of water-works which has caused a great deal of trouble in filling up the pipes and causing a brown sediment in the water is the so-called "iron bacterium," or crenothrix. It has the power of secreting iron in its sheath. Although it is a decided nuisance, it is not known to have any harmful effect on health.

Odors in Drinking-water.—These fall into three groups: (1) Odors caused by organic matter other

than living organisms, (2) odors caused by the decomposition of organic matter, (3) odors caused by living organisms.

The odors of the first group are usually characterized as musty, swampy, or peaty in character. Those due to the products of decomposition are similar to the odor given off by any organic materials undergoing decomposition. These odors when marked are decidedly offensive. The odors due to living organisms are the most impotent, since they may occur in water that has been purified by the most approved methods of filtration. For several years for brief periods the water supplied to a portion of the city of Philadelphia has had a very disagreeable oily or fishy odor that persisted after boiling and aërating the water. These odors are believed to originate from minute droplets of oil contained in microscopic water organisms, such as Diatomaceæ, Cyanophyceæ, Chlorophyceæ, and Protozoa.

The organisms producing the disagreeable odors in stored water are unable to grow in the absence of sunlight, and the most satisfactory method of inhibiting their growth in stored waters is to cover the reservoirs so as to exclude light. So far as known the odoriferous substances are not harmful, but they are decidedly objectionable, as most persons suffer from thirst rather than drink water containing them.

The more important *animal organisms* disseminated through water are the eggs and larvæ of certain animal parasites, as the eggs of the round worm, the eggs of Ankylostoma duodenale and Rhabdonema intestinale, and the larvæ of the Guinea-worm, all of which gain access through fecal matter. Amebic dysentery is another disease which it is believed may be carried in water.

The *gaseous impurities* in water are few in number and of somewhat doubtful importance. They are hydrogen sulphid, sulphur dioxid, and the gaseous emanations

arising from putrefaction, as ammonia, carbon dioxid, hydrogen sulphid, and marsh gas. These gases are usually found in water that is charged with the gaseous emanations from sewers.

The *solid impurities* are principally mineral particles, such as sand, clay, and fine particles of mica. These arise from the soil over or through which the water passes, and are most plentiful at the time of freshets.

Effects of Impurities in Water.—**Gaseous Impurities.**—Hydrogen sulphid and the gaseous emanations from sewers appear to produce diarrhea. Sulphur dioxid, when present in considerable quantities, produces disease of the bones in cattle.

Solid Particles.—Any water that is markedly turbid, even though the suspended matter be without disease-producing qualities in itself, may cause diarrhea. This is the case with the muddy waters of the Ganges, the Mississippi and other rivers, especially at certain seasons of the year; the turbidity being due to clayey particles along with vegetable matter. Finely divided mica scales are said to cause the "hill diarrheas" of certain districts of India. Suspended animal matters (especially fecal) cause diarrhea, and there is little doubt that such water predisposes to typhoid fever or cholera in some degree, by producing an irritated condition of the alimentary tract.

Dissolved Impurities.—**Inorganic Impurities.**—The inorganic impurities dissolved in water may be divided into three classes: The actively poisonous minerals sometimes found in water, as lead, zinc, and arsenic; the alkaline and earthy salts, and iron, derived from the soil; and those salts which, though not in themselves injurious to health, are indicative of the nature and extent of the pollution of the water.

The contamination of drinking-water by the poisonous metals is rare except in the case of lead. The solvent action of water on lead pipes is dependent upon a variety of conditions. The temperature of the water is an

important factor. Hot water dissolves lead much more readily than cold water. The character of the water is also an important factor. Soft waters, as a rule, are better solvents than hard waters. The presence of considerable amounts of dissolved oxygen in water sometimes acts as a solvent. Certain organic acids in water are also believed to act as solvents. Certain forms of micro-organisms seem to favor the solvent action. The amount of lead which will produce symptoms of poisoning is variously stated by different authors, ranging from 1 part in 700,000 to 1 part in 7,000,000 parts of water; though it is probable that any quantity over 0.7 part per 1,000,000 should be considered as dangerous. A number of propositions have been made to prevent the solvent action of water on lead pipe, such as coating the interior of the pipes with tin, fusible metal, or with coal-tar varnish. The safest method of preventing lead-poisoning is the substitution of iron pipes for lead pipes wherever possible. Since the solvent action is a rather slow process, there is very little danger from the plumbing of modern dwellings unless water is used which has been standing in the pipes for some time. For this reason the first portion of the water drawn in the morning should always be discarded, as it is the portion most likely to contain lead.

The alkaline earthy salts in water, constituting what is known as the hardness of water, are believed to exercise some effect on those constantly using hard waters. It is not easy to differentiate the effects of the several earthy salts, though the calcium salts appear to produce diarrhea, while the magnesium salts appear to be concerned in the production of goiter. Iron causes dyspepsia and constipation, and the sulphid is believed to be productive of goiter.

Organic Impurities.—Dissolved vegetable matters, if derived from marshes, are considered harmful. Any dissolved organic matter, whether vegetable or animal, if present in large amount, may produce diarrhea. The

animal matter derived from graveyards appears to be especially injurious. It must be borne in mind, however, that the effects here attributed to the organic impurities in water, in the light of our present knowledge, must be attributed largely to the influence of micro-organisms simultaneously present.

Bacteria.—The diseases produced by the presence of specific pathogenic bacteria in drinking-water are typhoid fever, Asiatic cholera, dysentery, and diarrhea, the latter possibly through the presence of Clostridium welchii. In addition to these diseases, diarrhea and dysentery may be produced through the presence of certain other micro-organisms in drinking-water.

Typhoid Fever.—The belief that typhoid fever can be communicated through drinking-water is comparatively modern, Austin Flint, in this country, and Alfred Carpenter, in England, about 1852, having been the first to establish the fact. It is now hardly questioned by any one that has studied the history of different epidemics. Hirsch considers that few points in the etiology of typhoid fever are so certainly proved as the conveyance of the specific bacilli by drinking-water or by food contaminated with polluted drinking-water. Bacterium typhosum is the actual cause of the disease, and no water can convey the disease without containing the specific organism.

A number of epidemics of typhoid fever have been traced directly to polluted drinking-water. The prevalence of typhoid fever in any community should always lead to an investigation of the nature of the water-supply and the removal of sources of pollution. Cities using polluted river- or lake-water always have a high death-rate from typhoid fever. Changing to a pure water-supply or the purification of the polluted water is followed immediately by a reduction in the mortality from typhoid fever. The reduction in the death-rate from typhoid fever at Lawrence, Mass., at Philadelphia, Pa., and other places after the introduction of filtered water, was most marked, and has continued low ever since. The reduc-

tion in the death-rate from typhoid fever in Newark and Jersey City, N. J., after abandoning the polluted water of the Passaic River for impounded surface-water, was also quite marked.

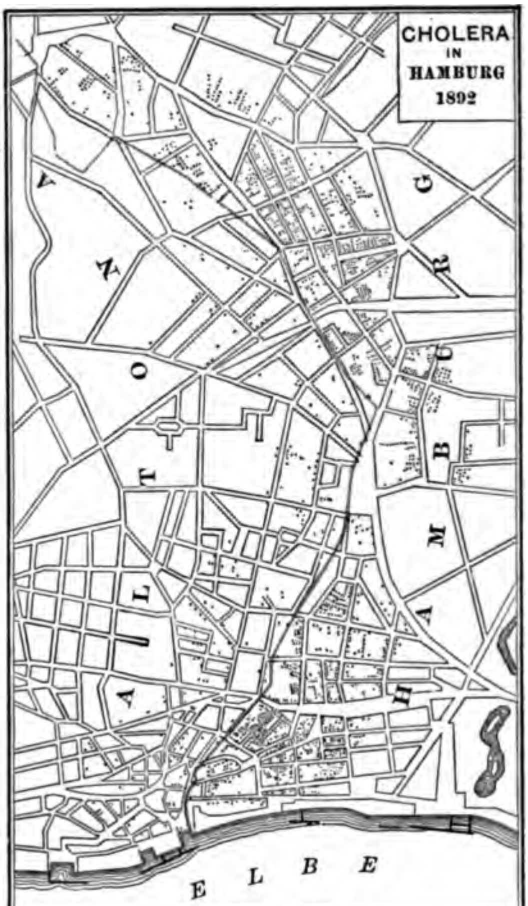


FIG. 23.—The black dots show the location and number of the cholera cases in both Hamburg (to the right of the red dividing line) and Altona (to the left of that line) (Abbott).

Asiatic Cholera.—The question of the spread of cholera by water is, in many respects, as well established as the spread of typhoid fever. The theory of the spread of

cholera through drinking-water dates back to the writings of Dr. Snow in 1849 and 1854. The specific organism of cholera is the "comma bacillus," or spirillum discovered by Koch in 1882 (Vibrio choleræ).

The relation of polluted water-supplies to outbreaks of cholera is shown most graphically in the accompanying chart (Fig. 23) indicating the experiences of the adjoining cities Hamburg and Altona, in 1892. Both cities derived their water-supply from the river Elbe. Hamburg used the raw, unfiltered water. The supply of Altona was taken from the river at a point below the Hamburg sewer outfall, but subjected to sand filtration. The two cities adjoin, and are practically one city; the division between the two for the most part follows one of the streets. There were 16,957 cases and 8606 deaths from cholera in Hamburg, and only 516 cases and 316 deaths in Altona during the same time, giving a death-rate of 1343 per 100,000 of population for unfiltered river-water, and a death-rate of 211 per 100,000 of population for filtered water. A number of the cases occurring in Altona were traced directly to infection by Hamburg water occurring in persons working in Hamburg but living in Altona.

Diarrhea and Dysentery.—Klein[1] believes Clostridium welchii to be the etiologic factor in many cases of diarrhea, and that it probably gains entrance to drinking-water through sewage and surface washings containing the fecal matter of domestic animals. Bacillus dysenteriæ is now generally regarded as most probably also carried in infected waters. Besides these, certain putrefactive organisms, such as those of the proteus and lactic-acid groups, are also believed to be concerned in the causation of diarrhea under certain conditions.

The discovery of Messrs. Duval and Basset[2] that "infantile diarrhea" is due to Bacterium dysenteriæ has

[1] *Report of the Medical Officer of the Local Government Board for* 1895–96 *and* 1897–98.

[2] *American Medicine*, vol. iv.

stimulated bacteriologists to extended studies upon the etiology and modes of transmission of diarrheal diseases in general. The greater prevalence of diarrheal diseases in hand-fed, as compared with breast-fed, infants points to the food-supply as the source or carrier of the infectious agent. The results of the investigations upon the bacterial content of milk indicate that the specific micro-organisms of infantile diarrhea gain access to the milk through contaminated water used in cleansing the milk-containers, or water added for purposes of dilution.

Goiter.—It has always been a widespread belief that goiter and cretinism are caused by the use of drinking-water from particular sources, and there is some foundation for this belief. These diseases appear to be associated, to some extent at least, with certain geologic formations, especially those localities in which magnesian limestone is found. Various observers have, in turn, considered the salts of calcium and magnesium, as well as other metallic substances, especially iron sulphate, or copper, or deficiency of chlorids or of iodin, to be the cause. Hirsch believes that endemic goiter should be considered as an infectious disease produced by a specific poison.

Approximate Composition of Drinking-water.—De Chaumont classified different waters into four classes, with regard to their degree of purity. This classification is serviceable in forming an opinion as to the usefulness of a water for domestic purposes, though it cannot be followed strictly in every particular, because geologic conditions may influence the constitution of a water to such an extent as to bring it under the class of suspicious or impure waters with regard to the mineral constituents, without really rendering the water suspicious. It is always necessary to have some knowledge of the geologic formation of the locality.

The table of approximate composition of pure, usable, suspicious, and impure waters should not be regarded as absolute because variations may occur in the waters of

certain localities which are traceable to the peculiar geologic formations of the locality and not to pollution. It is highly necessary to have a knowledge of the geologic formations that may have contributed some of their constituents to the water; otherwise serviceable waters may be condemned.

Chemical constituents stated in parts per 1,000,000.	Pure.	Usable.	Suspicious.	Impure.
	Less than	Less than		Over
Total solids	70.000	430.000	430.000 to 710.000	710.000
Chlorin	14.000	40.000	40.000 to 70.000	70.000
N as nitrates	0.140	1.120	1.120 to 24.000	2.400
N as nitrites	nil	nil	0.500	0.500
N as free NH_3	0.020	0.050	0.050 to 0.100	0.100
N as albuminoid NH_3	0.050	0.100	0.100 to 0.125	0.125
Organic matter	0.250	1.000	1.000 to 1.500	1.500

Amount of Water Required Daily.—**For Drinking and Cooking.**—An adult requires, on an average, 3 liters of water daily; of this amount, 1 liter is contained in the solid food that is ingested. About 2 liters should be allowed for drinking-purposes, either as plain water, or as tea, coffee, etc.

For Ablution.—The quantity used varies very much according to the cleanliness of the individual. About 25 liters may be allowed, of which 10 to 15 liters will serve for a sponge bath. If a general bath is taken, the daily amount is very much increased, and may be stated at from 250 to 300 liters.

For Laundry and Kitchen Use.—About 15 liters may serve for laundry purposes, and the same amount for house and utensil cleansing.

For Water-closets.—The usual quantity provided in the "water-waste-preventer" cisterns now supplied to closets is 10 to 15 liters. These contrivances effect a great saving in water and meet all the requirements.

For other Purposes.—The need of water in cities for other than domestic purposes, such as manufacturing, washing of sidewalks, sprinkling of streets and lawns, and for hospitals, brings the daily supply up to a very large

amount. The estimations of the Chief of the Bureau of Water of Philadelphia, of 750 liters per head per day, should meet all legitimate requirements. The supply of 890 liters per day shows that there is an enormous waste of water.[1] It is believed that a supply of 500 liters per person per day would be a generous supply of water for all purposes in cities and towns. The supply in many European cities is less than one-half as much. Most American cities have been extremely lavish in the supply of water. Since, however, it has become necessary to purify all domestic water supplies the amount of water supplied becomes a most important economic question. Wasting of water should be carefully controlled, but sufficient amounts should be supplied for all legitimate needs.

Source of Water-supplies.—Surface-water.—By surface-water is meant the water discharged from the surface of a catchment area, as opposed to that collected from wells and galleries. Strictly speaking, the water in rivers and lakes is surface-water; but as the supply from these sources is often obtained by special works it is convenient to restrict the term surface-water to supplies obtained by means of impounding reservoirs. Such surface supplies depend upon the rainfall for their existence and upon the natural features of the watershed for their character.

It is generally possible to secure statistics of the rainfall in the neighborhood of most places large enough to have water-works, and from such statistics and an inspection of the catchment area the probable amount of water usually available may be determined. The maps of the State and National geologic surveys are of much value in determining the sources from which a supply may be obtained.

The quality of the water from a watershed depends upon the population of the area, the number of swamps

[1] See "Report of the Mayor of Philadelphia on Extension and Improvement of the Water-supply," 1899.

in it, and the nature of the geologic strata over which it flows. If the population on the watershed exceeds about 100 per square kilometer, the stored water is in danger of being polluted, and often proves troublesome from bad taste and odor. If there are numerous swamps on the watershed, the water is likely to be dark in color, and may be objectionable on this account. If limestone is common, the water is liable to be too hard for either domestic use or for manufacturing purposes.

The suitability of the water for a municipal supply depends upon its freedom from sewage contamination, the degree of hardness, as well as its color, odor, and taste. Its general character may be determined by an inspection of the entire watershed.

Supplies from Rivers.—The nature and amount of water available from a river must be determined by systematic study of the flow at both high- and low-water seasons. The character of the river-water will depend upon the density of the population along its entire length, the nature of the surface-covering of the watershed, and the nature of the geologic formations.

In comparing the relative advantages of river-water and of impounded surface-water, it is necessary to take into account the amount of water obtainable from either source, the relative purity of each, and the expense of extending both systems so as to meet the demands of the future. This question had been under discussion in Philadelphia for a long time, owing to the degree of pollution of the water. Many competent observers had made more or less exhaustive studies of the conditions involved, but with varying results; some favoring the abandonment of the river-water and resorting to the use of impounded water from the headwaters of the tributaries of the Delaware and Schuylkill Rivers, others favoring the purification of the supply in use as being the most feasible and the less expensive procedure. The commission of experts appointed early in 1899 to make another detailed study of the whole question reported in

favor of filtration of the river-water. This plan has been adopted, and since 1914 the entire population of the city is receiving river-water that has been purified by slow sand filtration.

Lake and Pond Supplies.—The use of lakes and ponds as sources of supplies is not available for many localities. Where such supplies are available and they are of undoubted purity, they usually meet all the conditions. In the use of lake-waters the disposal of sewage, however, becomes a serious problem, as in Chicago. Here the sewage was disposed of by leading it back into the lake, with the result of polluting the lake-water to such an extent as to render it dangerous. Even carrying the fresh-water intake far out into the lake failed to remedy the matter satisfactorily, and, as a result, the drainage canal leading to the Mississippi River was constructed to dispose of the sewage.

Ground-water Supplies.—There are two classes of ground-water, the water which filters from a river or pond into the soil forming its basin, and the water which has entered the ground from a variety of sources, but has been checked in its downward percolation by more or less impervious strata.

The water of the first class retains many of the characteristics of the river- or pond-water from which it is derived, though the nature of the soil through which it passes influences its character to some extent, improving it during its passage through the soil. The water of the second class is influenced to some extent by the geologic formation of the locality and the depth to which it has penetrated. Generally it is a water of considerable purity.

With regard to the method of collecting ground-water, the general plans must vary with the particular conditions presented by the locality. These methods, in a general way, may be said to be either by means of a large circular well, of tubular wells, or of filtering and collecting galleries.

The amount of water that may be obtained from deep

and shallow wells depends upon the same conditions as those influencing the amount of surface-water. Besides this, the quantity is also dependent upon the porosity of the soil or its capacity for storing water. No more water can be obtained from an area drained by the well than that which falls upon the surface in the form of rain. The amount of ground-water is therefore somewhat limited. The largest yields of ground-water for the supply of cities in this country have been as follows:

Brooklyn, N. Y.,	150,000	cubic meters per day.
Memphis, Tenn.,	75,000	" "
Lowell, Mass.,	56,250	" "
Dayton, Ohio,	31,650	" "

The amount of water that could be obtained from this source would be only a small fractional part of the daily consumption of a large city. For small towns this source of supply is available when there is no other that is equally pure and more accessible.

Springs.—The relative purity of spring-waters renders these a useful source of supply. For small communities the supply is often sufficient for ordinary requirements, or it may be extended by combining the supply of neighboring springs. The nature of the location of many springs renders them but little liable to pollution, and at the same time it frequently renders the collection and utilization of the water an easy matter.

Artesian Wells.—In many localities the only available source of supply is that from artesian wells. The depth of the wells is dependent upon the depth at which water-bearing strata are to be found. The nature of the water obtained is influenced directly by the chemical composition of the strata through which the water has passed. As a rule these waters are quite hard, though of great purity. In certain localities, as in North and South Dakota, the waters are quite alkaline and contain mineral matter to the extent of 4000 to 5000 parts per 1,000,000 parts of water, or even more. The healthfulness of these waters is directly dependent upon the nature and

amount of mineral matter contained in them. It is evident that the constant use of such waters as those found in the Dakotas would prove of considerable injury to the organs of elimination, especially the kidneys. Experience has shown that these waters cannot be used constantly with impunity. They are usually used only when other available supplies fail from long-continued drought.

Reudiger[1] found that in portions of North Dakota people drink water that has an alkalinity of from 900 to 1200 parts per million, due to the presence of carbonates and bicarbonates. He traces the injurious effects of these waters with high mineral content to the presence of large quantities of magnesium and sodium sulphate. He believes that a water should be considered unsuited for drinking if it contains over 200 parts per million of magnesium in the form of sulphate. Waters with smaller quantities of magnesium sulphate may be injurious if considerable quantities of sodium sulphate are also present.

Storage of Water.—Water is stored on a large scale in reservoirs, and on a small scale in tanks or cisterns. Reservoirs are natural or artificial basins appropriated or formed for the purpose of reserving or storing water. They are called storage reservoirs when they are intended to retain the excess of rainfall during the rainy season; service reservoirs when they are intended to hold the supply for immediate distribution. Cisterns are necessary in houses supplied on the intermittent system, as in rural districts. The size of the cistern will depend upon several conditions, as the amount of supply required according to the number of persons occupying the house, and the frequency with which the supply can be replenished. The materials used in the construction of cisterns are usually cement and slate. These materials yield nothing to the stored water. Common mortar should not be used, because it gives up lime to the water. Neither should any metal be employed.

[1] *Am. Jour. of Public Health*, vol. iii., 1912.

Purification of Water.—The purification of water used for drinking-purposes may be directed to its physical, chemical, or biologic condition. Water that is turbid may be rendered clear; water that has a large amount of dissolved mineral impurities may be deprived of them, at least to some extent; water that contains micro-organisms, pathogenic or harmless, may be rendered almost or quite free from bacteria. Physical, chemical, and mechanical means are employed to accomplish these ends.

In former times mechanical purification alone was attempted, and a water that was clear and sparkling was considered fit to drink, no regard being had to its chemical and biologic impurities. With the advance in chemical science and application of the knowledge it afforded, the chief attention was directed to the mineral matters in solution, especially those indicating fecal pollution. Within recent years, since the cause and the mode of dissemination of certain epidemic diseases have been traced to the pollution of drinking-waters with sewage, the position is now taken that purification of water, to be efficacious, must not only render a water clear and free from mechanical and mineral impurities, but must also deprive it of the pathogenic bacteria contained therein. This latter function is now considered the most important in any process of purification.

Methods of Purification.—**Self-purification of Bodies of Water.**—The power of self-purification which many streams and lakes exhibit is in some instances quite remarkable. It was supposed, not long since, that polluted rivers would, in time, completely purify themselves. This has, however, been refuted by recent investigations. The process of self-purification in streams and lakes is a composite one. The factors which are concerned in this process are the following :

1. Sedimentation. The suspended particles, both organic and inorganic, sink to the bottom. 2. Oxidation. In consequence of the movement of the current the water

becomes aërated, and comes in contact with fresh portions of oxygen, and this oxidizes the organic matter. Sunlight accelerates the oxidation of the organic matter. 3. Precipitation. During the course of the stream certain insoluble inorganic compounds (as sulphur compounds) may be formed and precipitated, or humus substances may be precipitated through the action of clay, aluminum sulphate, and hydroxid. 4. Dilution. The entrance of pure water from the tributaries and from ground-water dilutes the water. 5. Water plants of different forms (as algæ) and infusoria digest dissolved and, at times, undissolved organic substances. 6. The bacteria convert the organic matter into simple inorganic compounds, such as carbon dioxid, ammonia, and water.

Jordan[1] studied the extent of the purifying power of bacteria in the Illinois River and its tributaries. Samples were collected at various points along the Chicago drainage canal and the Desplaines, Illinois, and Mississippi rivers. "In the flow of twenty-four miles between Morris and Ottawa, the river freed itself from a great mass of sewage bacteria with which it was originally laden, and at Ottawa this was not greatly in excess of that found in the flow of the tributary streams." He attaches most importance to the influence of sedimentation and to the diminution of the food-supply. Less influence is believed to be exerted by sunlight and the agencies of the animal and vegetable life in the stream. He believes that the influence of the diminution of the food-supply through the agencies of the bacteria themselves is a factor that has not received due consideration.

A very good example of the inadequacy of the self-purification of streams, in distances of 15 to 30 kilometers, is afforded by the Merrimac River, in Massachusetts. Epidemics of typhoid fever have followed one another, occurring first in Lowell, from two to three weeks later in Lawrence, and in one instance even in Newburyport. The refuse of one city was carried directly to the next, and the lower cities, using the river-

[1] *Jour. Exper. Med.*, Dec. 15, 1900.

water for drinking-purposes, were afflicted with serious epidemics. The dilution, sedimentation, and aëration were insufficient to remove the typhoid bacilli.

Filtration.—Filtration is one of the most satisfactory processes of purifying water. It was formerly supposed that the process was merely a mechanical one by which the particles suspended in the water were removed. While this is in part true, it is now well established that, besides removing suspended particles, the filtering process through properly constructed beds of sand will diminish the amount of organic matter in the water, while the bacteria are very much reduced in number. This process is similar to the natural processes of purification constantly going on in the soil, and is brought about through the activity of the same agents—the liquefying, the ammonifying, and the nitrifying bacteria. All well- and spring-water, the so-called ground-waters, have been filtered by the natural process.

The object of all filtration of water is purification. This purification, wherever necessary, should be carried out by the municipal authorities. In other words, a water should be furnished to the public which requires no purification at the hands of the consumers themselves.

Sand Filtration.—Filtration on a large scale, through sand and gravel, was first done in London, in 1839, when one of the city water companies subjected the water it was furnishing to the city to this process in order to remove turbidity. It is, however, only during the last decade that the matter of sand filtration has received a great deal of attention. Experiments have been made on large and small scales, from which many important facts regarding such filters have been obtained. It has been found that even raw sewage can be treated in this way with remarkable results, and in water 98 to 99 per cent. of the bacteria and a large proportion of the organic matter are removed.

Sand filtration is spoken of as intermittent or continuous, depending on the fact whether water is kept on the

filter continuously or not. The *continuous filter* is most useful in the following instances: When a city requires all the water a filter will take care of when running continuously; when the water is not greatly polluted; and when the conditions of temperature in winter are such that a certain amount of water must be kept on the filter bed in order to prevent freezing. The more rapid the rate of flow through the filter, the more impurities the filtered water will contain.

Intermittent filtration is resorted to when the water is highly polluted. A certain amount of air is necessary to complete the oxidation of the organic matter. Highly polluted water is deficient in dissolved oxygen, and hence the filter must be ventilated from time to time to allow the nitrifying bacteria to recuperate. When the flow of water is stopped the last portion of water, as it sinks down into the filter, draws the air after it, thus assisting in the aëration of the filter.

The continuous process of sand filtration is used successfully at Altona, Hamburg, Breslau, Berlin, Zurich, and London, in Europe, and at Lawrence, Mass., Berwyn, Pa., Nyack, Poughkeepsie, and Albany in New York, Superior and Ashland, Wis., Washington, D. C., Pittsburgh, Pa., and at Philadelphia, Pa.

The Lawrence filter removes, on an average, 98.3 per cent. of the bacteria contained in the river-water. The average number of deaths in the city from typhoid fever in previous years had been 43 for eight months, from October to May, while in the first year after starting the filter there were only 16. Of the 16 who died, 9 were operatives in the mills, and were known to have used unfiltered canal water for drinking. In 1898 there were only 8 deaths from typhoid fever, a death-rate of 1.39 per 10,000 persons living.

The slow sand filters for the purification of water are located on ground usually elevated somewhat above the level of the river, and the raw water is pumped on the filters, and after filtration flows by gravity to a basin, from whence it is carried in mains to the area to be supplied.

In Philadelphia and other places the river water is first passed through preliminary filters, where much of the mud and the grosser impurities are removed. These preliminary filters are constructed of crushed stones and coarse sand, through which the water passes by gravity at a rapid rate. These filters serve merely as strainers, as the water passes through too rapidly to undergo biological purification. When the loss of head in these filters has reached a point where experience has shown that it is necessary to clean them the filtration is arrested. The filters are cleaned by forcing up through the bed a current of compressed air to break up the layer of foreign material that has accumulated on the surface, after which a reverse current of water is forced up through the filter to wash the accumulated filth into drains which carry it to a sewer. These filters may require cleaning each day, depending on the amount of suspended matter in the raw water.

The final filters are of different construction. The filter bed is underdrained, and over these drains the filtering material is placed, and consists of a layer of stone and then coarse sand to a depth of about a foot and a layer of fine sand to a depth of three or four feet. The water coming from the preliminary filters flows by gravity on to the surface of the sand of the final filters and passes through the filter bed into the underdrains and from these to the filtered water basin. The size of the sand grains and the amount of head given to the water over the surface of the filter bed is governed by the character of the results obtainable under the local conditions.

The final filters act merely as strainers when the water is first applied, and several weeks to a month must usually elapse before the effluent is purified to a satisfactory degree. When this stage has been reached, an examination of the surface of the filter bed shows that a slimy layer has collected on top of the sand and penetrates to a depth of several inches. This layer is composed of the foreign material in the water and a felt-like mass composed of

bacteria, algæ, and other living organisms. These organisms are the active purifying agents, and bring about the biological purification of the water. The principal agents concerned in the purification of the water are the liquefying, the ammonifying, and the nitrifying bacteria which were brought to the filter in the applied water and have multiplied on top of and in the upper layers of the sand composing the filter.

As the amount of filth collecting on the filter increases in thickness, decreasing amounts of water pass through until finally the amount of pure water obtained is so small as to render the filter unprofitable. When this stage is reached the filter is cleaned. The cleaning operation of the final filters is accomplished by allowing all the water to drain off, and then with shovels the filth and an inch or two of the upper layer of the sand bed are removed. This material is then removed from the filter and passed through a sand washing machine. These washing machines are now so constructed that they can be placed on the surface of the scraped filter and the filth and dirty sand are shoveled into the machine and washed with a stream of pure water, the filth being carried to the outside through one pipe while the washed sand is allowed to flow on to the surface of the filter bed. In this manner the depth of sand composing the filter diminishes slowly and the life of the filter is very much prolonged.

After a filter has been cleaned the effluent is impure until such time as is necessary for the re-formation of the slimy layer on the surface. Until the effluent reaches a satisfactory degree of purity all the water passing through the filter is allowed to flow into a sewer and returns to the river.

The preliminary filters, as well as the final filters, are built in sections, so that while one section is being cleaned the other sections continue in operation, consequently only a portion of the filtering area is out of commission at a time, and the remainder of the area is in undisturbed

operation. The cleaning of the final filters and the time required until they again operate efficiently amounts to about 15 per cent., and hence the filtering area must be increased to that extent over the area required if the filters could be operated continuously.

The effluent of the final filters is examined daily as to its bacterial content and at longer intervals as to its chemical nature. It is possible to control the character of the work performed by each unit, and use or discard the effluent of any unit whenever its character is satisfactory or unsatisfactory.

The greater part of the purification of water in a sand filter is carried out on or near the surface of the filter. The slimy pellicle which forms on the surface of the filter is composed largely of so-called bacterial jelly, and it is the bacteria in this pellicle that accomplish the purification. The efficiency of a filter is very low until this pellicle has had time to form, and when it is removed the efficiency of the filter is destroyed. Aside from this surface film, or "schmutzdecke," as the Germans call it, the individual sand grains in the upper portion of the filter are also covered with a coating of a similar nature.

The action of the filter as a whole must be taken into account. There is undoubtedly much mechanical work accomplished in the actual removal of the larger, troublesome, but not particularly dangerous organisms, and of the turbidity and sediment. This, however, is not the most important action of the sand filter. There is also a chemical action going on, an oxidation or burning up of the organic matter, and this is mainly due to the vital force in the filter—the bacteria.

The changes which take place in the water as the result of filtration through a sand filter are as follows:

Removal of solids in suspension	100 per cent.
Reduction in free ammonia	50 to 75 "
Reduction in albuminoid ammonia	35 to 50 "
Reduction in oxidizable organic matter	25 to 30 "
Increase in nitrates	25 to 30 "

The rate of filtration should not exceed very much 1.5

cubic meters per square meter of surface, though it may vary, according to the relative purity of the unfiltered water, from 2,000,000 to 5,000,000 gallons per acre daily (22,000 to 56,000 cubic meters per hectare).

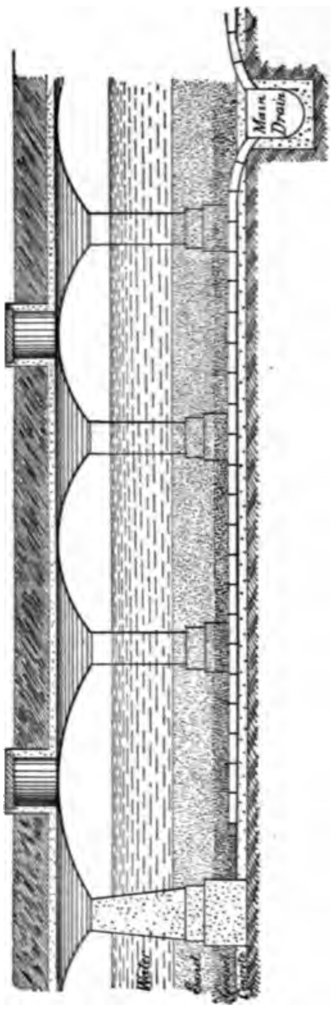


FIG. 24.—Section of covered sand filter.

The height of water on the sand filters, or the amount of head, as it is called, in the continuous process of filtration varies according to the practice which is found to give the best results, the average depth of water being 50 to 75 centimeters, though many of the German filters contain as much as 100 to 125 centimeters.

The efficiency of sand filters is dependent, to some extent, upon the size of the sand particles composing the filter. The range of the size of the sand grains is from 0.09 to 0.38 of a millimeter in diameter. Within certain limits, the finer the sand particles the greater the efficiency of the filter.

When first constructed, the thickness of the sand layer ranges from ¾ to 1½ meters. On account of the process of scraping, which is necessary to clean the filter from time to time, the thickness of the sand layer is reduced, and authorities differ as to the extent of the reduction that is permissible;

some allowing a reduction to a depth of 3 decimeters; others contending that the reduction should never be greater than to 6 decimeters before the sand is replaced. Fig. 24 shows a section of a covered sand filter such as is in use at Albany, N. Y., and similar in form to those constructed at Philadelphia and Washington.

In cold climates it is necessary to cover the filters in order to prevent freezing. In warm latitudes the filter should be covered over to prevent undue heating of the water. It is also advisable to cover the filters in order to exclude sunlight and thus prevent the growth of algæ, and to exclude dust.

The efficiency of large sand filters may be demonstrated, first, by a reduced mortality from typhoid fever and from cholera after the introduction of the filter. The bacterial efficiency of sand filters ranges from 98.1 to 99.93 per cent. The chemical efficiency of some of the London filters is such that all of the ammonia is removed, others removing from 75 to 80 per cent. In each instance the total solids are slightly reduced, the organic carbon and organic nitrogen are uniformly reduced; showing that sand filtration effects an appreciable reduction in the amount of organic matter.

The entire city of Philadelphia is now served with filtered water. The influence of the filtered water on the incidence of typhoid fever has been such as to cause a reduction of more than 80 per cent. It is safe to assume that most of the typhoid fever now occurring in the city is due to milk infection and to contact cases.

Rapid sand filtration[1] was first introduced at Somerville, N. J.,[2] in 1885. Many cities and towns have since adopted this method. The largest plants in use are at Cincinnati, O., Columbus, O., Hackensack, N. J., Harrisburg, Pa., Little Falls, N. J., Louisville, Ky., Toledo, O., New Orleans, La., Minneapolis, Minn., and Grand Rapids, Mich. Filter plants of this nature

[1] George A. Johnson, *Water-supply Paper*, No. 315, Washington, D. C.
[2] *The Ohio Public Health Journal*, Vol. VII, No. 11, p. 436.

have also been installed at Alexandria and Cairo, Egypt, and at Tokio, Japan.

The rapid sand filters are employed in the purification of waters having a high turbidity. The suspended matter in these waters would soon clog the surface of a slow sand filter and so render it useless. In the rapid sand filtration process coagulants are added to the water before filtration. The coagulant most commonly employed is aluminum sulphate, though ferrous sulphate may also be employed, but is more expensive and less efficacious. When carbonates are also present, the coagulant added to the water forms a soft, flocculent precipitate which settles on the surface of the sand and forms a mat which strains out all suspended matters in the water, including most of the bacteria. The rate of filtration is about forty times as great as in the slow sand filter, and hence there is no chance for biological purification because this method of filtration is dependent upon the straining effect of the precipitate on the surface of the sand. The greater the amount of suspended matter in the water, the quicker the filter becomes useless from the accumulation of matter on its surface and the more frequently the filter has to be cleaned. These filters are cleaned by forcing filtered water up through the filtering material and carrying the mud and impurities into a sewer. After a filter has been cleaned the water which passes through it is at first grossly polluted, and only becomes fit for use when a sufficient amount of precipitate has been deposited on the surface of the sand to serve as an efficient strainer.

In addition to the use of the coagulant, other chemicals may also be used to soften the water, as is done at Columbus, Ohio, and other places where the hardness of the treated water makes such treatment desirable.

This type of filter is usually constructed of a number of small units, and additional units are added as the town grows in population. The initial cost of the rapid sand

filters is lower than that of the slow sand filters, but the expense of operation is higher. The water purified by the rapid sand filtration method is of satisfactory sanitary quality provided the process is carried out properly.

Water purification plants have multiplied very rapidly in thickly populated communities within the last decade, so much so that in several states nearly one-half of the total population is receiving water that has been purified in one way or another.

WATER FILTRATION PLANTS IN NINE STATES, 1916.[1]

State.	Number of Plants.	Total Capacity of plants, M. G. D.	Population Served.		
			Total.	Percentage of Total Pop. of State.	Percentage of Urban Pop. of State.
Pennsylvania	123	900	3,960,000	46.7	75.5
Ohio	42	465	2,205,000	43.0	72.3
New York	68	...	825,000	8.1	10.0
Maryland	9	139	659,000	48.5	94.5
Illinois	38	110	500,000	8.2	12.6
Indiana	17	88	500,000	17.8	41.4
Minnesota	7	34	326,000	14.4	33.0
California	7	26	235,000	8.1	12.0
Michigan	6	45	227,000	7.5	14.7

Numerous mechanical filters are now on the market which permit the rapid filtration of large volumes of water through limited sand areas, and, in most instances, under considerable pressure. A number of these mechanical filters make use of some coagulant, such as alum or iron, in order to assist in clarifying and purifying the water. The flocculent precipitate which is formed takes with it the suspended matters as well as the bacteria, and the whole mass is caught on the surface of the sand as the water passes through. Usually these filters are cleaned by turning the water in the reverse direction, thus washing the

[1] *The Ohio Public Health Journal*, vol. vii., No. 11, p. 436.

filth, which has accumulated on the sand, into the sewer. Small filters of this nature are employed to filter the water of manufacturing establishments, of hotels, hospitals, and of private dwellings (see Fig. 25); larger sizes arranged in series, are now also employed to filter the

FIG. 25.—Mechanical filter: A, inlet pipe; B, outlet pipe; C, waste pipe; D, valve to cut off water from filter; E, lever to operate the agitator; F, air valve; H, handle of valve used to change the course of the water through the filter; I, distal attachment of coagulating tank to inlet pipe; K, lever valve regulating the quantity of alum supplied; O, proximal attachment of coagulating tank to inlet pipe; P, waste pipe leading from the coagulating tank to the sewer; Q, valve which fastens on the cover of the coagulating tank; S, pointer which indicates the course of the water through the filter; T, sight glass.

water of municipalities where the nature of the impurities in the water makes it impossible to obtain satisfactory results by sand filtration. A great deal of objection has been raised by persons not fully informed on the subject, against the use of alum as a coagulant. If the alum is used intelligently, there is not the slightest danger from its use. It is converted into aluminum hydroxid, a white flocculent precipitate, and is retained on the surface of the sand in this form. Unless unusual amounts are used, none of it will be found in the filtered water.

Another form of mechanical filter in use is that in which spongy iron and scrap iron are used as coagu-

lants. In these filters there is an additional item of expense in the revolving machinery which is necessary to agitate the iron in the water. The scrap iron is contained in a revolving cylinder through which the water passes. After passing through this cylinder the water flows on to a sand filter. This process is not adapted to the purification of brown, peaty waters, because the iron forms a soluble compound with the organic matter in these waters. A mechanical filter of this kind has been in successful operation at Wilmington, Del., for some years, and at Quincy, Ill.

The nature of the water and soil of a locality influences the kind of purification that will be most efficient. This can only be determined by a series of systematic tests. Such tests and studies have now been made at Louisville, Cincinnati, Providence, St. Louis, Pittsburg, Columbus and Lorain, Ohio, Washington, D. C., and at Philadelphia.

No city should be satisfied unless it possesses the best possible water-supply. The importance of having a supply of pure water must be evident. A municipality should be compelled to furnish its citizens with a water-supply which does not need house filtration nor boiling to render it safe. The insurance companies have brought the matter to a focus by making the quality and quantity of a municipal water-supply one of the factors in determining the insurance rates. The life-insurance rates are sometimes increased if the water is polluted, and the fire rates are increased if the quantity of the general water-supply is considered insufficient. One or more such cases of increased rates have occurred recently in the State of Indiana. No problem connected with modern municipal life is of greater vital importance than the purification and protection of the water-supply.

The attention which has been given to the purification of water-supplies has produced remarkable results with regard to the conservation of the health of people living in urban communities. These effects are seen

especially in the progressive reduction in the death-rate from typhoid fever. The figures in the following table have been collected by the Journal of the American Medical Association:

TYPHOID IN CITIES OF THE UNITED STATES IN 1919.
(*Jour. Amer. Med. Assoc.*, March 6, 1920, vol. lxxiv, p. 672.)

GROUP 1 (OVER 500,000 POPULATION).

	Deaths from typhoid per 100,000 population.				
	1919.	1918.	Average, 1916–1919.	Average, 1911–1915.	Average, 1906–1910.
Chicago	1.2	1.4	2.7	8.2	15.8
New York	2.0	3.7	3.4	8.0	13.5
Boston	2.2	2.5	2.8	8.0	16.0
Cleveland	2.4	4.7	4.9	10.0	15.7
Philadelphia	4.4	3.9	5.3	11.2	41.7
Detroit	5.3	10.0	12.0	18.1	21.1
St. Louis	5.8	7.2	7.5	12.1	14.7
Pittsburgh	6.2	9.8	8.9	15.9	65.0
Baltimore	8.9	12.2	13.6	23.7	35.1
GROUP 2 (FROM 300,000 TO 500,000 POPULATION).					
Newark, N. J.	2.1	3.5	3.6	6.8	14.6
Seattle	2.3	2.3	3.1	5.7	25.2
Cincinnati	2.6	4.1	3.5	7.8	30.1
Minneapolis	3.1	7.6	5.6	10.6	32.1
San Francisco	3.3	4.6	4.0	13.6	27.3
Milwaukee	3.5	6.2	7.6	13.6	27.0
Washington	3.7	11.9	10.3	17.2	36.7
Los Angeles	4.7	2.8	3.9	10.7	19.0
Buffalo	7.0	7.8	8.9	15.4	22.8
New Orleans	13.7	20.1	20.0	20.9	35.6
GROUP 3 (FROM 200,000 TO 300,000 POPULATION).					
Jersey City	2.2	4.1	4.0	7.2	12.6
Columbus, O.	3.0	8.9	8.2	15.8	40.0
St. Paul	3.0	3.5	3.4	9.2	18.3
Denver	3.2	8.7	6.0	12.0	37.5
Providence, R. I.	3.4	4.5	4.6	10.2	14.3
Portland, Ore.	3.6	5.6	4.8	10.8	23.2
Rochester, N. Y.	3.8	1.9	3.4	9.6	12.8
Indianapolis	4.7	6.6	11.9	20.5	30.4
Louisville, Ky.	9.0	12.4	10.8	19.7	52.7
Kansas City, Mo.	11.2	13.7	11.3	16.2	35.6

GROUP 4 (FROM 125,000 TO 200,000 POPULATION).

	Deaths from typhoid per 100,000 population. 1919.	1918.	Average, 1916–1919.	Average, 1911–1915.	Average, 1906–1910.
Spokane, Wash.	0.0	9.1	4.5	17.1	50.3
Scranton, Pa.	1.3	5.2	4.4	9.3	31.5
Worcester, Mass.	2.8	4.6	3.9	5.0	11.8
Fall River, Mass.	3.0	7.0	9.4	13.4	13.5
Toledo, O.	3.1	9.9	11.4	31.4	37.5
Oakland, Calif.	3.2	4.7	3.4	8.7	21.5
Richmond, Va.	3.7	7.5	10.5	15.7	34.0
Paterson, N. J.	4.2	2.1	4.7	9.1	19.3
Omaha	4.4	5.0	5.2	14.9	40.7
New Haven, Conn.	5.7	5.2	7.0	18.2	30.8
Syracuse, N. Y.	6.7	9.3	8.6	12.3	15.6
Atlanta, Ga.	9.6	14.4	14.6	31.4	58.4
Birmingham, Ala.	14.6	31.9	35.8		
Memphis, Tenn.	58.4	15.9	32.6	42.5	35.3

GROUP 5 (FROM 100,000 TO 125,000 POPULATION).

Hartford, Conn.	0.9	7.0	6.8	15.9	19.0
Tacoma, Wash.	1.6	5.7	3.3	10.4	
New Bedford, Mass.	1.6	8.0	4.8	15.0	16.1
Cambridge, Mass.	1.7	2.7	2.4	4.0	8.9
Springfield, Mass.	2.6	3.6	4.3	17.6	
Camden, N. J.	2.7	3.6	5.3	4.5	
Lowell, Mass.	3.4	1.8	5.8	10.2	13.9
Bridgeport, Conn.	3.8	3.9	5.7	5.0	10.3
Dayton, O.	4.5	6.9	9.9	14.8	22.5
Grand Rapids, Mich.	5.1	10.3	10.8	25.5	29.7
Salt Lake City	5.4	7.1	10.2	13.2	
Reading, Pa.	6.1	12.3	11.1	31.9	42.0
Trenton, N. J.	6.8	9.4	8.7	22.3	
Albany, N. Y.	7.6	10.7	9.1	18.6	17.4
San Antonio, Tex.	9.6	54.3	26.6	29.5	
Dallas, Tex.	12.2	12.6	17.9		
Nashville, Tenn.	15.8	32.7	23.5	40.2	61.2

Household Filters.—Household filters may be divided into two large classes, those which filter all the water supplied to a house, as small forms of the different types of mechanical filters, and those which filter only the portion used for cooking and for drinking purposes. A variety of filters is now on the market that is intended for this purpose. The essential characteristics of a good filter of the latter class may be stated as follows:

A. With regard to the *filtering medium:*

1. It should have sufficient purifying power, mechanically, to restrain all suspended matters; chemically, to remove dissolved organic or deleterious matter; and biologically, to arrest micro-organisms.

2. This purifying power should be reasonably lasting.

3. The filtering medium should give up to the water nothing that is either itself deleterious or that will favor the growth of low forms of life.

FIG. 26.—Domestic filter—Berkefeld: *a*, point of attachment to faucet; *b*, outlet.

4. The delivery should be reasonably rapid, consistent with efficient purification.

B. With regard to the *filter construction:*

5. It should be so constructed as to be easily taken apart, inspected and cleaned.

6. There should be nothing that is liable to decay or capable of yielding up metallic or other impurities to the water.

The domestic filters of this class which meet all these conditions most satisfactorily are the Berkefeld filter (see Fig. 26), composed of cylinders of baked infusorial earth, and the Pasteur filter, composed of cylinders of baked, unglazed porcelain. These filters yield a water that is clear and sparkling, free from bacteria, and are readily taken apart and cleansed. After having been in use for several days the filtered water begins to show the presence of bacteria owing to the fact that these organisms have grown through the pores of the filter. For this reason these filters must be cleansed at frequent intervals. This cleansing should consist in scrubbing the outside of the cylinder and then boiling or baking for an hour. After such a cleansing they are almost as efficient as new filters.

Purification of Water without Filtration.—The proc-

esses of purification, aside from filtration, which may be employed, are distillation, boiling, and treatment with chemical substances. *Distillation*, if properly carried out, furnishes a pure water. It is, however, deprived of its oxygen and carbonic acid, and consequently it is tasteless. To remedy this defect a number of special distilling apparatuses have been devised which aërate the water at the same time (see Fig. 27).

Boiling, next to distillation, furnishes a harmless water, though it does not remove the dissolved impurities, and at the same time it removes the gases dissolved in the water. It renders the water tasteless. Boiled water may be aërated to some extent by pouring it from one vessel to another. Boiling removes the temporary hardness, the hydrogen sulphid, and renders the dissolved organic matter and bacteria harmless.

FIG. 27.—Domestic water still.

Where a water is objectionable merely on account of the bacteria contained in it, and there is danger of contracting one or the other of the water-borne diseases, a satisfactory mode of domestic purification is that by means of the Forbes water sterilizer (Figs. 28 and 29), in which the water is boiled and cooled during its passage through the apparatus, issuing from the apparatus with its temperature but little higher than at the point of entrance.

The treatment of water by means of *chemical substances* is conducted with the object of precipitating suspended matters, as by means of the salts of aluminum; the removal of hardness, by the addition of lime; to oxidize the organic impurities present, by the addition of potassium permanganate; the removal of pathogenic bacteria, as in the treatment with ozone, bromin, or hypochlorites.

Crystallized alum is very effectual in the precipitation

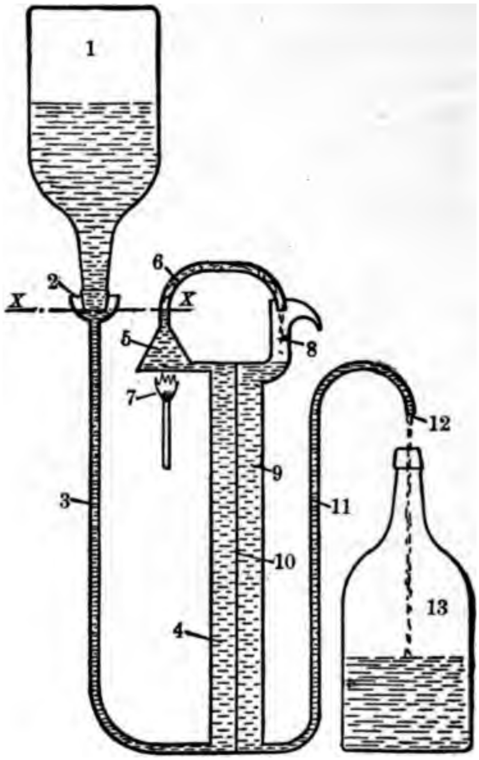


FIG. 28.—Forbes' portable water sterilizer, for use in the absence of a general water-supply. The raw water is supplied from the inverted bottle 1. The water runs from the bottle 1 into the cup 2, then down through the pipe 3 into the compartment 4 of the heat exchange, which it fills. When compartment 4 is filled, the water runs into the heater 5, and rises in the pipe 6 to the level *X*, where it stops. No more water will now run out of the bottle 1, because its mouth is sealed by the water in the cup 2 at the level *X*. The burner 7 is now lighted, and heat is applied under the heater 5, which causes the water in the heater to boil, and in boiling it rises in the pipe 6 and flows over into cup 8, just as a pot on a cooking range will boil over. It is therefore impossible for any water to pass through the apparatus until it has boiled, for it is only by boiling that it can rise sufficiently in the pipe 6 to flow over into the cup 8. The water continues to boil over into the cup 8, and quickly fills compartment 9 of the heat exchange. When compartment 9 is filled, the water runs out of the pipe 11 at the opening 12 into the receiving bottle 13. While passing down through the compartment 9 the heat of the water, which is boiling hot, is transferred, by conduction, through the thin metal partition or diaphragm 10 to the cold water passing up through compartment 4, so that the water which is boiled in the heater 5 passes out of the apparatus nearly as cold as that entering, while the cold water entering the apparatus becomes heated as it passes up through compartment 4, and reaches the heater 5 nearly at the boiling-point.

of suspended matters in the propotion of 5 or 6 milligrams to the liter of water. The action is most marked if calcium carbonate is present. Calcium sulphate is

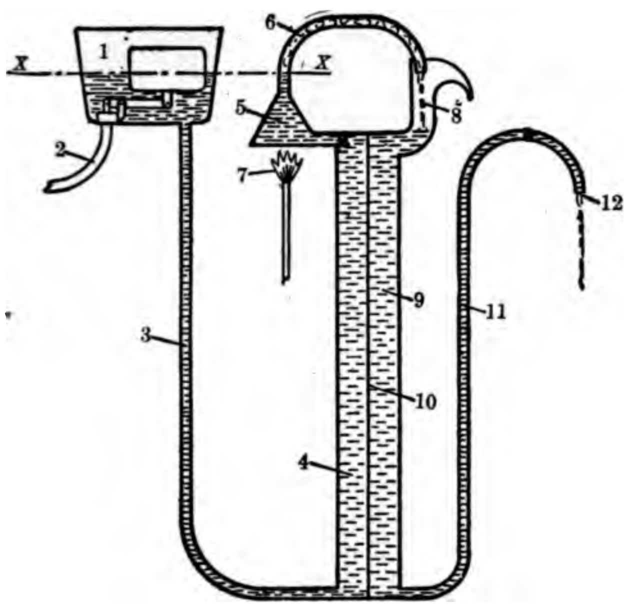


FIG. 29.—Forbes' stationary water sterilizer. The principle of operation of this apparatus is identical with that of the apparatus shown in Fig. 28, but the construction is slightly different. In this apparatus, 1 shows a water tank with a pipe, 2, through which water enters, and is allowed to fill the tank up to the water level *X*, but no higher, as it is restrained by the float-actuated valve shown in the tank.

The small tank with the float and valve merely take the place of the inverted bottle and aërostatic feed used in the first apparatus. Both the aërostatic device and the float and valve have the same functions, viz., maintaining the water level at the line *X*. In the second apparatus the pipe 2 is connected with a constant water-supply, such as a faucet or the water-supply pipe of the house.

After the water leaves the float box it runs down through the pipe 3, and the action of the apparatus from this point on is exactly like that of the portable sterilizer shown in Fig. 28.

formed, and a bulky precipitate of aluminum hydoxid which carries down the suspended matters. The water may then be filtered or on subsiding the clear water may be decanted.

Softening of Hard Waters.—Water is softened—that is deprived of its temporary hardness—by the addition of lime-water. The lime combines with the carbon dioxid existing free in the water, forming calcium carbonate. This is precipitated together with the calcium carbonate and magnesium carbonate previously existing in solution, because they are rendered insoluble by the removal of the free carbon dioxid.

At Winnepeg, Manitoba, the following results were obtained:

	Untreated.	Treated.
Calcium	91.5	21.1
Magnesium	67.6	42.8
Sodium	167.2	167.8
Iron and Aluminum	Trace	Trace
Silicic acid	7.3	4.2
Sulphuric acid	172.9	172.4
Chlorin	242.0	242.0
Hardness, as $CaCO_3$	510.4	231.1

The hardness of the water due to other salts of calcium and magnesium is not affected by this treatment. The reaction which takes place on the addition of lime-water is as follows:

$$CaH_2O_2 + CaCO_2CO_2 = 2CaCO_3 + H_2O$$
$$2CaH_2O_2 + MgCO_3CO_2 = 2CaCO_3 + MgH_2O_2.$$

Great care must be exercised in regulating the amount of lime-water added to a hard water. This amount can be determined only by chemical tests.

Carbonate of sodium is efficacious for softening water for washing purposes, but it is unsuitable for water used for drinking purposes, as it leaves an unpleasant taste. Soda-ash combined with caustic lime is used for the softening of water for boiler purposes for the removal of sulphates and chlorids.

Sterilization of Water by Means of Chemicals.—A large number of chemicals have been recommended for the sterilization of water, namely, alum, lime, salt, potassium and calcium permanganate, sulphate of iron,

chalk, cholorid of iron, chlorid of lime, acetic acid, citric acid, formalin, sulphuric acid, alcohol, chloroform, iodin, chlorin, bromin, ozone, sulphate of copper, hypochlorites, etc. Upon bacteriologic experimentation it has been found that some of these are without any effect, while others require a very long time for their action. Many of them are objectionable on account of the fact that they discolor the water or alter its taste and odor in such a manner as to render the water unsuitable for domestic use. The more these facts are borne in mind, the smaller the number of chemicals that can be used satisfactorily for the sterilization of water, and in practice only the following have proved serviceable—namely, chlorin, bromin, and ozone. The use of chlorin for the disinfection of water has found application in a number of localities where other methods of purification were not available. The chlorin is added in the form of calcium hypochlorite in amounts ranging from 2 to 10 mg. of free chlorin per liter of water (five to ten pounds of hypochlorite of lime to a million gallons of water). A contact of about two hours should be allowed for the action of the chlorin. The amount of calcium hypochlorite employed should be carefully regulated in accordance with the amount of organic matter in the water. Excessive quantities of the disinfectant are to be avoided, not only because of the possible detrimental effects of the chlorin, but also because of the needless expense.

A number of cities are using hypochlorites of lime or soda for the treatment of their water-supplies. In some instances the chemical is added to unfiltered water that is satisfactory except in its bacterial content. In other cities the chemical is added intermittently to the effluent of filter plants when the rate of filtration is pushed to such an extent as not to permit satisfactory purification.

Because of the inherent difficulties encountered in the use of calcium hypochlorite for the disinfection of water it has been found possible to use liquid anhydrous chlorin to much better satisfaction. Since 1917 Chicago has been applying liquid chlorin to all the water supplied

to the city, and the value of this procedure is shown in the very low typhoid death-rate for the city.

Bromin is used in the form of potassium bromid solution (60 mg. free bromin per liter of water). For the removal of the bromin from the water after it has been acting for a sufficient length of time the addition of ammonia or sodium sulphate or sodium carbonate is required. Investigations have demonstrated that bromin is not capable of satisfactorily sterilizing water when applied on a large scale.

Ozone seems to sterilize water satisfactorily in large quantities. This requires electrical apparatus such as is constructed by Siemens and Halske. In the application of ozone to the sterilization of water it is necessary to determine definitely the quantity of oxidizable matter in the water. The larger the quantity of such matter, the greater the quantity of ozone required, and consequently the greater the cost of operation. The relation between the ozone utilization and the oxidizable matter in the water must be under constant control, so that an excess of ozone may be supplied at all times. The ozone, when present in sufficient quantities, kills all bacteria in the water without in the least affecting the taste, odor, or color of the water, and the excess of ozone remaining in the water after the sterilization disappears in a short time. This method of purification is expensive and requires constant, intelligent oversight.

Disinfection of Water with the Ultra-violet Light. The application of the ultra-violet rays to the disinfection of water is made possible by the Westinghouse sterilizer. In this apparatus the water streams through a chamber in which it is exposed to the ultra-violet rays generated with a mercury-quartz lamp. Studies conducted with this apparatus by von Recklinghausen[1] show that with the use of less than twenty-six watt hours per cubic meter of water more than 600 cubic meters of water could be disinfected in twenty-four hours, and frequently the water was sterilized. All colon bacilli were killed. v. Recklinghausen

[1] *Gesundheits-Ingenieur*, 34 Jahrg., 1911, p. 166.

believes that from the low cost for operation and the high efficiency of the method this method of disinfecting water has a bright future.

Suitability of Water for Boiler-purposes.—The suitability of water for boiler-purposes is largely an engineering question, though it is also of importance to the householder, because the conditions are the same in the boiler of the kitchen range or of the heating apparatus as in the boiler of a manufacturing establishment. Water may be unsuitable for boiler-purposes on account of its corroding action or on account of scale-formation. Water of the greatest purity is not always the best for boiler-purposes, because of its solvent action. This corrosive action may be increased by the oxygen and carbon dioxid in solution in the water. The corrosive action may also be due to the presence of organic and mineral acids in the water. Waters collected from swampy regions are usually rich in organic acids, while the waters derived from mines are rich in mineral acids. Water may also possess a corrosive action because of the presence of soluble chlorids, especially sodium and magnesium chlorids. Oils may also favor the production of corrosive substances.

The corrosive action of water may be minimized or prevented by the removal of turbidity, by the addition of alkalies to neutralize the acidity, heating the water to drive off dissolved oxygen, while the action of the soluble chlorids may be prevented by the addition of the substances which will be described as useful in preventing scale-formation.

The ingredients in water which are most frequently concerned in scale-formation are the salts of calcium and magnesium. The amounts of silica and iron are rarely sufficient to cause scale-formation of any note. The most objectionable salt in water, with regard to scale-formation, is calcium sulphate.

Scale-formation is prevented by the neutralization of the carbon dioxid in the water. This acid operates in holding the calcium and magnesium carbonates in solu-

tion. The carbon dioxid may be driven off by heating the water before it passes into the boiler, so as to precipitate a portion of the calcium and magnesium. The carbon dioxid may also be neutralized by the addition of slaked lime or caustic soda to the water. These will combine with the carbon dioxid and precipitate it as well as the salts of calcium and magnesium.

Water and Sewage Analysis.—Sanitary analysis of water and sewage consists of a microscopic examination, a physical and chemical analysis, and a bacteriological analysis. For details of the microscopic examination the student is referred to Whipple's book (Whipple, "The Microscopy of Drinking-water," Wiley & Sons, New York, 1899). For details of methods of the chemical and physical analysis the student is referred to the standard methods of the American Public Health Association and to the author's "Handbook of Practical Hygiene" (Bergey, "Handbook of Practical Hygiene," The Chemical Publishing Company, Easton, Pennsylvania, 1899). For details of the bacteriological analysis the student is referred to the standard methods of the American Public Health Association and to Prescott and Winslow, "Elements of Water Bacteriology."

Collection of Samples.—In each instance samples should be collected in colorless, glass-stoppered bottles that are scrupulously clean. For the bacteriological analysis the container must have been sterilized. The sample for microscopic examination should consist of at least 1 liter; that for the chemical and physical analysis at least 4 liters; and that for the bacteriological analysis at least 200 c.c. The samples should be collected with great care so as to avoid surface scum or particles on the surface, as well as sediment deposited on shore of streams to be sampled. For shipment the stoppers and necks of the bottles and the bottles should be covered with a muslin cap and the bottles should

be packed in cases having compartments into which the bottles fit rather closely. These compartments should be lined with corrugated paper, felt, or other substance so as to prevent breakage. In warm weather or when shipment is to be made over a considerable distance, it is necessary to have the containers packed in ice so as to keep the temperature as low as possible to prevent multiplication of the bacteria and alteration of the organic matter in the water.

Microscopic Examination.—The microscopic examination should be carried out as soon as possible. In no instance should the sample be in transit for more than twenty-four hours. In case the sample contains fragile organisms, immediate examination is advisable, otherwise these may be lost when the water has been shipped some distance. The microscopic examination is especially important in that it will indicate the nature of the organisms in the water which give rise to various odors in water that may be wholly satisfactory as far as its chemical, physical, or bacteriological content may be concerned. According to Whipple the distinctive odors produced by microörganisms may be grouped around three general terms—aromatic, grassy, and fishy.

Physical Examination.—The physical examination includes observations of the temperature, color, turbidity, odor in hot and cold samples, and sediment.

The temperature should be taken at the time of collection.

The color is preferably determined by comparison with the platinum-cobalt standard (Winslow and Walker, "Science," 1907, Vol. 26, p. 675) or by the United States Geological Survey Field Method which consists in comparing the color of the water with that of glass disks in the end of metallic tubes. This compares very favorably with the platinum-cobalt method.

The turbidity of the water is determined by comparing

it with standards prepared by suspending silica in distilled water.

The odor should be noted in both the cold sample and the sample which has been warmed to just below the boiling-point. The American Public Health Association has adopted the following classification of amounts of odors:

Numerical Value.	Term.	Approximate Definition.
0	None.	No odor perceptible.
1	Very faint.	An odor that would not be detected ordinarily by the average consumer, but that could be detected in the laboratory by an experienced observer.
2	Faint.	An odor that the consumer might detect if his attention were called to it, but that would not attract attention otherwise.
3	Distinct.	An odor that would be detected readily and that might cause the water to be regarded with disfavor.
4	Decided.	An odor that would force itself upon the attention and that might make the water unpalatable.
5	Very strong.	An odor of such intensity that the water would be absolutely unfit to drink. (A term to be used only in extreme cases.)

Pure water on standing shows no deposition of sediment, but water containing matter in suspension will show varying amounts of sediment which may be termed as very slight, slight, distinct, decided. In the case of sewage, considerable sediment will be formed on standing.

Chemical Analysis.—The determinations that are considered necessary for a satisfactory sanitary chemical analysis of water or sewage are as follows: residue on evaporation, total and dissolved, with the loss on ignition in some instances; total nitrogen, nitrogen as albuminoid and free ammonia, nitrites, and nitrates; oxygen consumed; chlorine; dissolved oxygen; hardness; alkalinity; incrusting constituents; iron; sulphuric acid and carbonic acid. For details of the methods of conducting

these determinations the reader is referred to the texts already announced. The importance of these different constituents varies with the material to be analyzed. In the analysis of surface or ground waters the analyst is especially concerned in discovering evidences of pollution, while in the analysis of filtered waters he is interested more particularly in determining the stages of the process of purification secured by the plant that is being studied. In the analysis of sewage he is interested in determining the amount of decomposable material still present, in order that he may indicate to what extent further purification may be necessary to render the material unobjectionable when finally disposed under the conditions prevailing in a particular locality.

Bacteriological Analysis.—The bacteriological analysis of water may consist of either quantitative determinations or qualitative determinations of the bacteria in the water. In the quantitative analysis water is plated on standard nutrient agar in such quantities that the plates shall have not more than about 200 colonies each in order that estimation of the colonies may be made quickly and accurately, and also to prevent the inhibiting action of neighboring colonies on each other. It is now customary in most laboratories to incubate the plates at 37.5° C. for forty-eight hours. It is recognized that at this temperature the typical water bacteria are excluded, but since these have no important sanitary significance and as time is an important element in reaching a decision as to the character of the water, it is generally regarded as best to incubate for a briefer period at a higher temperature than was formerly regarded necessary. Waters that contain large numbers of bacteria must first be diluted with sterilized water before they are plated, but where the relative number of bacteria cannot be known it is advisable to plate several dilutions, say, 1 to 100, 1 to 1000, 1 to 10,000 dilutions, according to the number of bacteria suspected

of being present. In the analysis of sewage even higher dilutions are necessary.

The qualitative analysis of water may take several important directions, depending upon the primary object in making the analysis. The water is usually placed in lactose-litmus agar in order to ascertain the number of acid-producing colonies. This is a rough indication of the number of organisms of the colon group contained in the water. Another presumptive test for the presence of the colon bacillus consists in inoculating some of the water into fermentation tubes containing lactose broth or lactose-bile medium, using fractional parts of a cubic centimeter so as to reach the point where the water is diluted to such an extent as not to have any of the fermenting bacteria in some of the dilutions of water inoculated. For water which contains relatively few organisms of the colon group two distinct methods of determining this fact have been in use: First, inoculating large quantities of water, say 50 c.c., into the lactose-bile medium; second, inoculating 10 c.c. samples in five fermentation tubes containing lactose-bile medium. Pure water should not have more than two colon bacilli in 100 c.c. Where the number of colon bacilli is much higher than this there is presumptive evidence of pollution of untreated water or imperfect purification of treated waters. The qualitative analysis of water at times also calls for the detection of some of the specific bacteria causing gastro-intestinal infection, especially the typhoid bacillus and the cholera organism. The detection of these organisms requires the use of special methods for the enrichment of the culture whereby the specific organisms are caused to develop and the accompanying bacteria are inhibited, and subsequently the enriched culture is plated out on special plate media. Details of these methods may be found in the standard methods of the American Public Health Association.

CHAPTER V.

THE REMOVAL AND DISPOSAL OF SEWAGE.

THE term *sewage* includes not only human excreta, solid and liquid, but also the waste water and impurities coming from human habitations. The term sewage, however, does not include such impurities as proceed from manufactories, such as the refuse from dye-works, gas-works, etc.; these are termed manufacturing impurities. From a hygienic standpoint the human excreta are the most important constituents of sewage. The sewage of towns usually contains, besides human excreta and household wastes, the water used for washing and sprinkling streets, as well as the rain that falls which is not stored for household use. The total quantity of sewage depends largely upon the amount of pure water supplied per head per day. Sewage has an average composition of 998 parts of water, 1 part of urine, and 1 part of organic matter.

The Removal of Sewage.—The removal of sewage from the dwelling is accomplished by several different methods. That in general use in towns is by means of water. This system necessitates the introduction of the necessary waste pipes for the removal of the sewage itself, the introduction of a supply of water sufficient to flush out the drain pipes and keep them free from sewage. It also necessitates arrangements for the disposal of the sewage.

Water-closets.—Where water is employed for the removal of sewage the water-closet forms a most important

factor in the system. The qualities required by all the appliances of a water-closet are durability, simplicity, accessibility, cleanliness, and general effectiveness. The

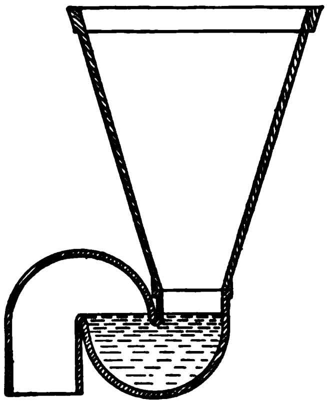


FIG. 31.—Hopper closet.

principal forms of closet that are now in use are the hopper (Fig. 31), some form of wash-out or wash-down

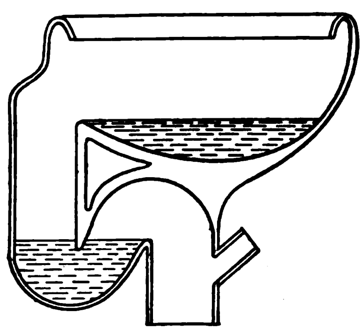


FIG. 32.—Wash-out closet.

closet for private dwellings (Figs. 32, 33), and the trough closet or latrine for schools and public institutions.

The supply of water for the wash-down closet is obtained by the introduction of a separate cistern, used exclusively for the water-closet, generally termed a "water-waste

FIG. 33.—Wash-down closet.

preventer" (Fig. 34), because only a limited supply of water is available for delivery. The amount of water usually supplied in the cistern is about 15 liters. The

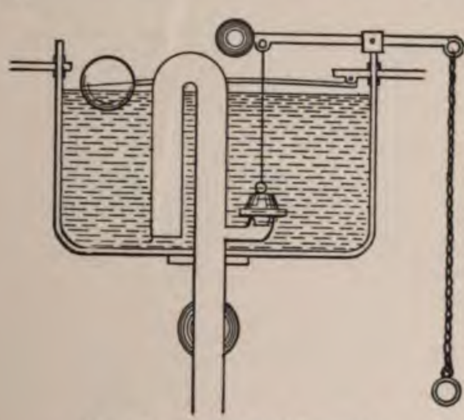


FIG. 34.—Water-waste preventer.

cistern is placed at some height (not less than a meter) above the closet, and has an exit pipe of considerable size, so that the water may descend with sufficient force to flush effectually the closet.

The position of the closet chamber is of importance. It should always be arranged along the outer wall of a building, so as to afford ventilation into the open air, and not into an air shaft. The closet itself should be along the inner wall, opposite a window, so as to afford plenty of light to detect any defects.

The arrangement of a bath-room, in which all the

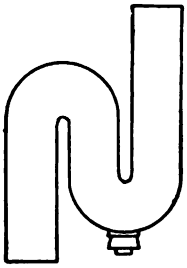


FIG. 36.—S-trap.

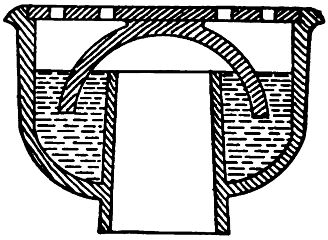


FIG. 37.—Bell-trap.

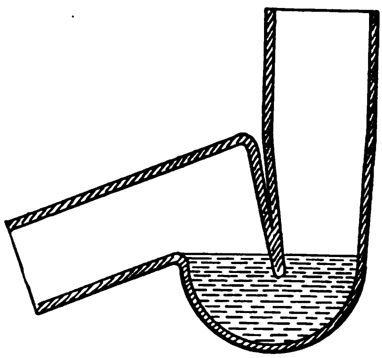


FIG. 38.—Anti-D trap.

modern improvements in the sanitary removal of sewage are supplied, is shown in Fig. 35. In the modern dwellings now being constructed the conveniences supplied in bath-rooms are important factors in conserving the health of the individual as well as of the community.

Traps.—A trap is a bend in the pipe which is filled with water so as to prevent the entrance of sewer or drain air into the house. It consists of a water seal in the pipe.

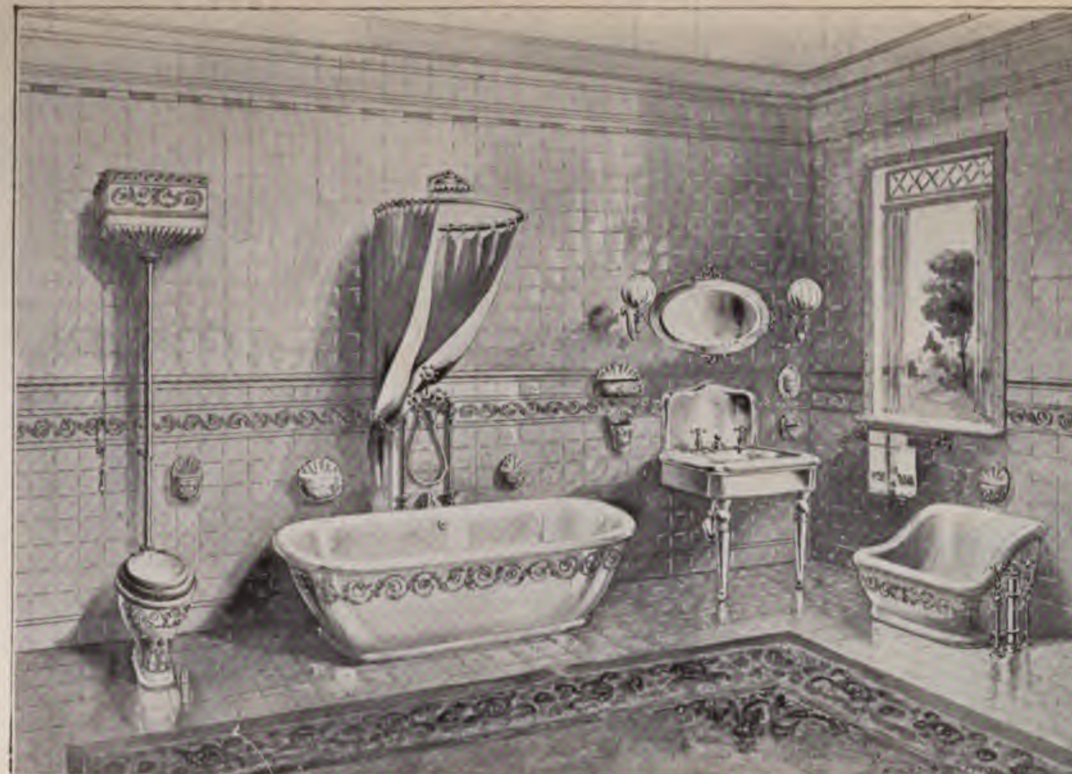


FIG. 35.—Arrangement of a modern bath-room (Trenton Potteries Co.).

All appliances on the drainage pipes of a house, such as water-closets, sinks, etc., must be supplied with a trap. The different forms of traps in use are the S-trap, the

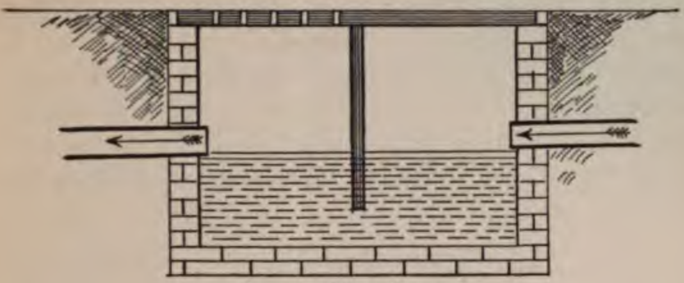


FIG. 39.—Mason's trap.

bell-trap, the anti-D trap, and Mason's trap (Figs. 36, 37, 38, and 39).

Soil Pipe.—The pipes for carrying away the sewage

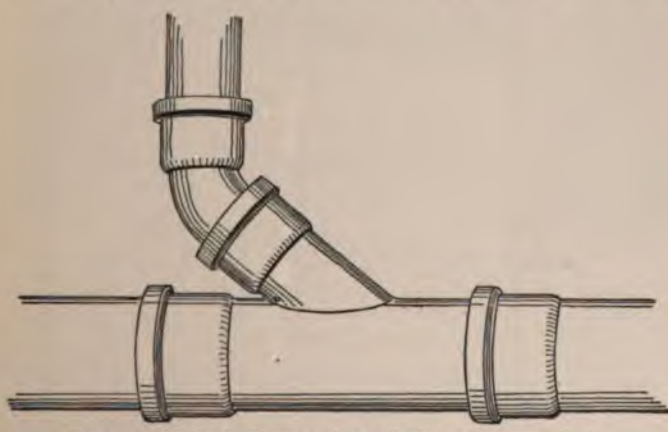


FIG. 40.—Method of connecting soil pipe with house drain.

from a house are called soil pipes. For an ordinary dwelling the soil pipes should be constructed of heavy iron tubing, with tight joints, circular in shape, and 10 centimeters in diameter. The interior of the soil pipe must be smooth, so as not to impede the flow of the sewage. The soil pipe is ventilated through the warming of its contained air, causing an upward current, the fresh air entering

through a ventilator opening on the outside of the house next the point of disposal, and takes its exit through the upper end of the pipe, which is carried up over the roof of the building. The soil pipe should have an S-shaped trap between the ventilator opening and the sewer. All connections of drainage pipes with the soil pipe must be absolutely tight, and should be made at an acute angle, not at a right angle with the soil pipe (Fig. 40).

Where several closets on different floors discharge into

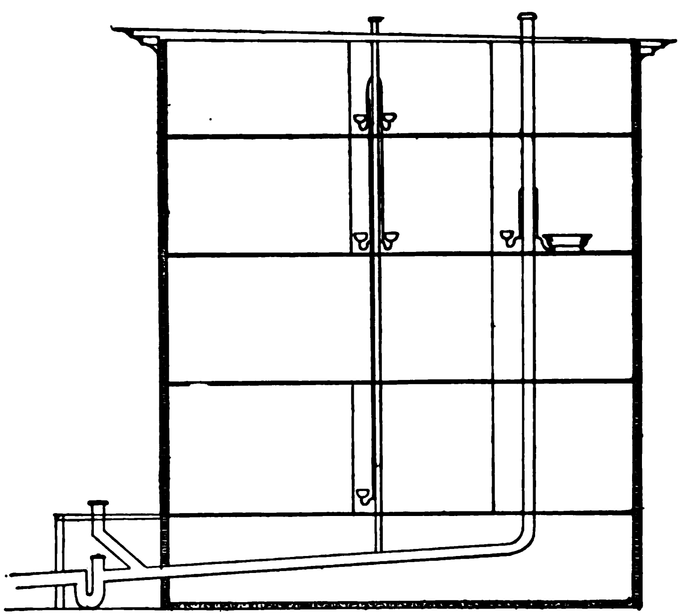


FIG. 41.—Arrangement of soil pipe.

the same soil pipe, the suction of the water in the soil pipe causes the trap of the other closet to become unsealed. To obviate this defect the traps are supplied with a separate ventilating pipe of small diameter, which enters into the soil pipe above the highest appliance of the system. These extra pipes also serve to ventilate the traps and pipes, and for this reason this is frequently spoken of as the "back-airing" of traps. It serves to

supply fresh air to the pipes, and thus serves to prevent the growth of anaërobic bacteria in the unventilated portion of the traps. This prevents the generation of disagreeable odors. The method of ventilation of soil pipe and the traps is represented in Fig. 41.

The required amount of fall for house drains may be determined according to the following rule: Multiply the diameter of the drain in centimeters by 4; thus a 10-centimeter drain should have a fall of 1 in 40; a 15-centimeter drain 1 in 60, and so on. If the distance from the

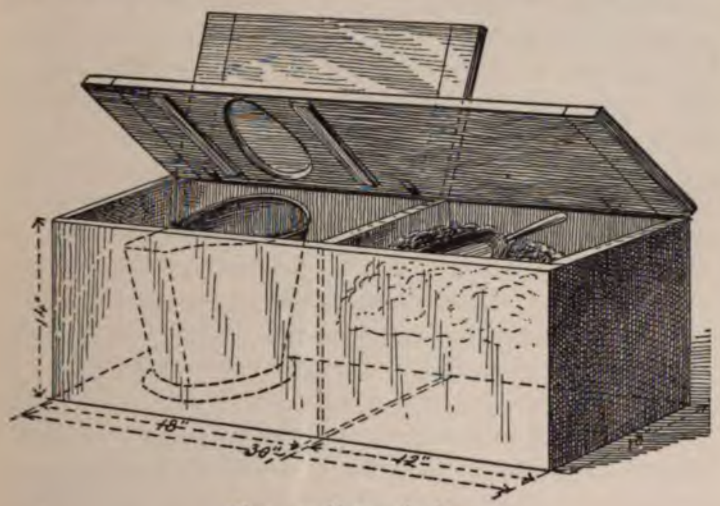


FIG. 42.—Dry-earth closet.

appliance to the soil pipe is too great to obtain the requisite amount of fall in the limited space between floor and ceiling, it will be necessary to have extensions from the soil pipe from the basement to the roof to receive these drains.

Another method of sewage removal is usually spoken of as **the dry method.** The pail system and the dry-earth closet are the principal types of the dry methods of sewage removal. In the pail system the excreta are simply received in boxes or tanks, and these are emptied whenever necessary. In the dry-earth closet a receptacle

containing dry earth is placed in the closet and about ½ kilogram of dry earth is thrown over each evacuation (Fig. 42). The earth is a natural deodorizer and the mass remains inoffensive for a long time, the fecal matter being finally entirely disintegrated. A separate receptacle is supplied for the collection of the urine. This system is the least objectionable in such localities where a general water-supply is not available, or where the climate is too severe to render a water-closet safe and serviceable.

Disposal of Sewage.—The question of the disposal of sewage is distinct from that of sewage removal, but the method of disposal is dependent, to some extent, upon the method of removal. In the dry methods of removal the final disposal of the fecal matter is as fertilizer upon cultivated land. If the removal is by means of water, this will be either partial, as to a cesspool, and hence further removal, after longer or shorter intervals, as well as final disposal, may be necessary, or the removal may be partial through a sewerage system and final disposal into streams or large bodies of water, treatment by precipitation processes, or by the various methods of purification.

In rural districts where there is no general sewerage system the house drains usually discharge into cesspools or tanks for the storage of sewage. Cesspools differ in their construction and mode of operation according to the nature of the soil in which they are located. Where the soil permits and the amount of space is sufficient, the cesspool may be constructed so as to allow the fluid portion of the sewage to drain away at once. Where no wells are near enough to be affected by this process the cesspool may operate for a long time without being cleaned out. Where the nature of the soil does not permit this mode of disposal of the fluid portion of the sewage, or where there is danger of infecting neighboring wells, the cesspool should be so constructed as to be impervious. Under these conditions it will require

frequent cleansing, the contents removed serving as fertilizer. Such a cesspool should be removed from the house and well as far as possible, and in such a position that the flow of the ground water is always in the direction from the well toward the cesspool.

A large majority of towns discharge their sewage into neighboring streams. All new works of this nature are prohibited in England. In Ohio and Pennsylvania health authorities also have the power to prohibit new works of this nature wherever the stream serves as a source of water-supply for another town further down its course. The effect of discharging sewage into streams is such that the streams are polluted to an extent sufficient to destroy the fish contained in it. Such water is always injurious to health when used for drinking-purposes. The Rivers' Pollution Commission of England reached the conclusion that none of the rivers of England were long enough to purify themselves by the natural agencies after having been polluted.

Towns along the seaboard find the easiest and most economical method of sewage disposal is to discharge it into the sea. There are, however, objections to this method. If the discharge is made near a watering-place, it will injure the bathing. The sea-water will also cause the precipitation of certain constituents of the sewage, and this matter will cause the formation of a barrier or reef along the shore, unless it is carried out into deep water.

As an indication of the methods of sewage purification employed to-day the following data are given, showing the practice in various parts of the State of Ohio.[1] From 1893 to 1912 inclusive 46 municipal purification plants have been constructed and 32 plants for institutions. The population served by the municipal plants is 456,600 and by the institutional plants 16,900. The methods employed for municipalities are: Sedimentation, 4; sedimentation and disinfection, 1; sedimentation and inter-

[1] Dittoe: *Monthly Bulletin, Ohio State Board of Health*, vol. cxi., 1913.

mittent sand filtration, 19; sedimentation and sprinkling filters, 2; preliminary sedimentation, sprinkling filters, and final sedimentation, 2; sedimentation and single contact filters, 10; sedimentation, contact and intermittent sand filtration, 6; natural land filtration, 1; sedimentation and coarse grain filters, 1. For the year 1913 there were in contemplation 18 additional purification plants to serve a population of 196,400. These new plants are of the following types: Sedimentation and intermittent sand filtration, 6; sedimentation and contact filters, 1; two-story tanks, primary and secondary contact filters, 2; two-story tanks, contact filters and intermittent sand filters, 1; two-story tanks and simple contact filters, 6.

Dittoe states that the fundamental consideration to be given in determining upon the required degree of treatment of sewage to avoid nuisance is the dilution afforded by the volume of the flow of the stream. One of the most important difficulties encountered in preventing stream pollution is the failure to secure proper operation of the sewage treatment plants after they are installed, and has led to the adoption of the simpler methods, wherever possible, instead of the more refined methods, which require more careful management.

Chemical Treatment of Sewage.—Where there is removal by water, but no opportunity for disposal into streams or other bodies of water, the sewage may be subjected to one of several processes of precipitation. The sewage is sometimes first strained to remove the coarser particles by passing it through screens. The materials employed in precipitation processes are lime and ammonium sulphate; lime and iron protosulphate; the ABC mixture, consisting of alum, blood, and clay; and ferrozone and polarite. The precipitated matter, or sludge, as it is called, is used for fertilizing purposes, and the fluid portion is discharged into streams.

Precipitation works are in use in the following cities of England: Acton, Ealing, and Sutton, and the process

is still partially in use at Manchester, though here a portion of the sewage is treated by several of the modern methods of purification. Precipitation works are also in use at Frankfort-on-the-Main, at Alliance, O., and at Worcester, Mass., though at the latter place a portion of the sewage is purified by filtration.

The various methods of chemical treatment of sewage may be divided into the following groups:

1. Intermittent treatment in tanks from 1.5 to 2.5 meters deep, in which, after the addition and incorporation of the chemicals, the sewage is allowed to remain until the completion of the process.

2. Continuous treatment in a series of tanks through which, after the addition and incorporation of the chemicals, the sewage flows slowly; crude sewage and chemicals passing in at one end, and purified effluent passing out at the other.

3. Vertical tanks through which the sewage rises slowly after the addition of the chemicals.

There are a number of variations of these three systems, but none of them is important enough to justify further subdivision into classes.

The conditions necessary for success from chemical treatment are as follows:

1. The sewage should be treated while fresh.

2. The chemicals should be added to the flowing sewage and thoroughly mixed with it before it passes into the settling tanks.

3. There should be a liberal amount of tank space.

4. The arrangements for the removal of the sludge should be such as to insure its frequent removal.

The sludge obtained by the treatment of sewage is often a further trouble, because it has to be finally disposed of. It may be burned, or it may be used for fertilizer if it can be disposed of in this manner. At Manchester, England, much of the sludge has been used in filling in low land adjacent to the precipitation works.

Modern Methods of Sewage Purification.—The old theory that filth containing pathogenic organisms would, when exposed to the sun, propagate various diseases, has been entirely overthrown. Experimentally and practically, sewage has been discharged upon land, which may or may not have been prepared to receive it, with the result that the pathogenic organisms and the offensive nature of the material are most effectively destroyed.

If the sewage is discharged onto a piece of land for the purpose of enriching the soil for raising crops, it is known as irrigation; if it is discharged over a large area, it is called broad irrigation; if it is discharged upon land specially prepared to receive it, with no idea of raising crops, it is known as filtration.

In broad irrigation the fields should be divided into sections 10 to 15 meters square, which are raised in the middle; or if the fields are uneven in contour, they should be raised into ridges of corresponding width. The sewage is conveyed to the middle of the section through an open drain. At certain distances dykes are placed in a drain, which cause the sewage to overflow on the slopes of the section. In order to operate satisfactorily, and carry the sewage to all parts of the field, it is discharged upon the field intermittently, either automatically by means of a Field flushing tank (Fig. 43) or by opening and closing sluices whenever a discharge is desired. In cold latitudes the operation of the irrigation field is inhibited by frost, as the absorptive power of the soil is feeble at low temperatures. From a sanitary standpoint the system has had a most careful investigation, especially in England, and these observations have failed to show the origin of any case of contagious disease from it.

Since 1870, when the Rivers' Pollution Commission of England proposed in their report the purification of sewage by irrigation of cultivated land, the system has been introduced into over 145 English towns. Other

European towns have also adopted it, including Berlin, Breslau, and Dantzig. In America it has been introduced at Wayne, Pa., Pullman, Ill., Greenfield, Mass., and Kitchener, Ont. In the western States, where there is a scarcity of water, sewage has been utilized for irrigation with considerable success. In California, Fresno, Pasadena, Redding, Los Angeles, Santa Rosa, and Stockton, all irrigate with sewage. In Colorado, Colorado Springs and Trinidad utilize sewage for irrigation purposes.

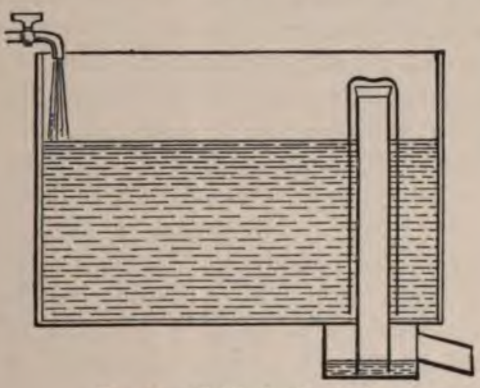


FIG. 43.—Field's flushing tank.

Helena, Mont., and Cheyenne, Wyo., also utilize sewage in this manner.

In order to operate satisfactorily the system requires 1 acre of area for each 2000 persons (2 square meters per person), and consequently it is not adapted for localities where cheap land in sufficient quantities and of suitable quality cannot be obtained. Large towns must, therefore, usually avail themselves of some other method of sewage purification.

Purification by Filtration Through Sand.—The filtration of sewage through specially constructed sand filters, or through a natural sandy, loamy soil, is efficacious in the purification of sewage. Because of the absence of free oxygen in sewage the filtration must be carried on by the intermittent method in order to give the nitrifying bacteria an opportunity to recuperate. These filters

are usually operated for half a day and then allowed to rest the second half of the day. This necessitates the construction of two filters that can be operated alternately.

Experimentally, much work has been done at the Lawrence, Mass., Experiment Station upon intermittent filtration, by passing sewage through various depths of different soils. It was found, among other results, that some forms of bacteria would pass through certain filters more readily than others; that in certain cases where the total number of sewage bacteria had increased while the sewage was passing through the filter, the number of species of bacteria had greatly diminished.

Intermittent filtration has been in practical operation for some time at Chichester and Sutton, England, and at Gardner, Marlborough, Clinton, South Framingham, Medfield, Worcester, and Brockton, Mass., Summit, N. J., East Cleveland, O., Hastings, Neb., Vassar College, Poughkeepsie, N. Y., and the Iowa State College, at Ames, also recently adopted this system of purification. In all of these towns the system employed is practically a combination of filtration and irrigation. The effluent water from this combined filtration and irrigation method in no way indicates its origin by temperature or smell. It may easily be mistaken for spring-water, as it comes out of the pipe clear and sparkling.

At Amherst, Mass., the sewage is collected in a stone tank 450 x 600 x 180 centimeters in size, divided into two equal compartments, in which the sewage is allowed to settle. This arrangement allows one compartment to be cleaned of its sludge while the other is receiving the sewage. The sludge is removed once a week. The effluent flows through a pipe to the river, about 150 meters distant. No further purification of the sewage is attempted. This method is obviously incomplete, and should be used only as a preliminary step to irrigation, filtration, or chemical treatment.

The following table shows the average results of continuous filtration through $10\frac{1}{2}$ feet of coarse broken stone, at an average rate of 1,897,000 gallons per acre daily for six days in the week, from May to November, inclusive (parts per 100,000):

FILTRATION THROUGH COARSE BROKEN STONE.

	Sewage.	Effluent.
Temperature, degrees Fahr.	63	63
Free ammonia	3.47	0.7265
Albuminoid ammonia	0.57	0.0963
Chlorin	7.58	5.96
Nitrogen as nitrates	——	1.88
Nitrogen as nitrites	——	0.1247
Oxygen consumed	3.72	1.09
Bacteria per c.c.	2,049,000	144,000
Dissolved oxygen, percentage of saturation	——	38

Subsurface Irrigation.—Another method of sewage disposal which is available for small towns or for isolated dwellings or hotels in rural districts, is what is known as subsurface irrigation. In this system pipes with open joints are distributed underneath the garden or lawn through which the sewage flows and percolates through the open joints into the soil. This system requires the introduction of a flushing tank in order to carry the sewage to all parts of the system. The household drains empty into a large flushing tank, having a capacity of about 15 cubic meters, separated into two chambers by a wire-cloth strainer to hold back obstructing material. A certain amount of sludge accumulates in the bottom of the tank and has to be removed at intervals. This system requires about 40 square meters of area for each person (1 acre per 100 persons).

Sludge Digestion.—The heavier portions of sewage which settle on standing give the most trouble in sewage purification. A number of methods have been devised to accomplish the disintegration of the sludge.

It has been found that the methods in which the sludge is exposed to the action of the anaërobic bacteria give the most satisfactory results. Of the sludge digestion tanks,

those which are in common use to-day are the so-called septic tank of Cameron and the Emscher tank.

Activated Sludge.—The accumulation of sludge in the different processes employed in sewage purification has been a feature that has now become less troublesome in what is known as the "activated sludge" digestion process. This consists in providing for the continuous aëration of the sewage as it passes through the digestion tank. The rate of nitrification of the organic constituents of the sewage is greatly enhanced in this process.

The Cameron Septic Tank.—Within recent years the purification of sewage on a large scale has been studied experimentally and practically in what is known as the septic tank or bacterial treatment of sewage (Figs. 44, 45). This system utilizes the dissolving and liquefying action of anaërobic species of bacteria in one portion, the

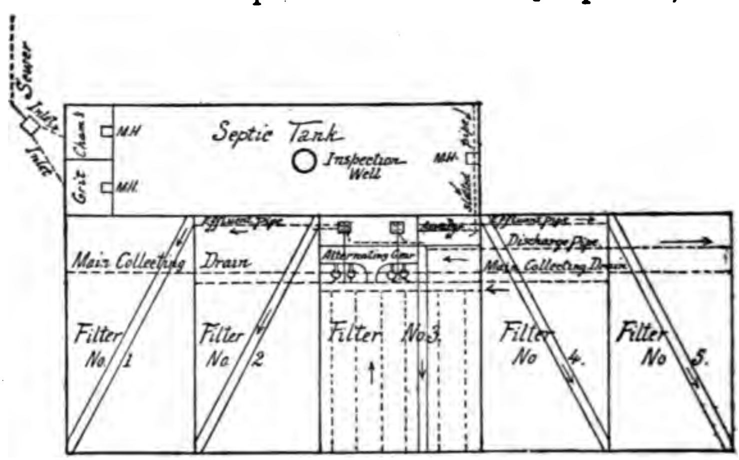


FIG. 44.—Arrangement of septic tank and series of filter beds.

so-called septic tank, and the oxidizing action of aërobic species of bacteria in another portion, the filter beds, several of which are arranged in series. Various modifications of the system are in use in England and America, all being on the general plans proposed by Cameron. The sewage is discharged into settling basins, from which it is transferred to the septic tank. In some of the works the septic tank is made practically air-tight, so as to

facilitate the growth of anaërobic species. In others it is simply an open tank, the idea being that since the sewage is devoid of free oxygen, therefore the conditions are favorable to the development of the anaërobic species, because the surface scum which forms renders the access of air without effect. Some of the action which it is proposed to obtain in the septic tank has already taken place in the sewage during its course to the disposal works. The flow of the sewage through the tank is regulated so that the solid matter may undergo solution and liquefaction, and is then discharged upon the first series of four or five filters, on which a mixed action of anaërobic and aërobic bacteria takes place, bringing about the breaking down of the intermediate dissolved bodies. These filters are operated automatically, so that one fills after the other. When the last filter begins to fill, the first filter discharges its contents. From these primary filters the sewage is discharged on to another set of filters, the secondary or aërobic filters, where the oxidation process is completed. In some of the works the sewage is discharged on to the secondary beds by means of a revolving sprinkler. Some of the works are without the secondary filter beds. The filter beds are composed of various kinds of material, as clinkers and coke.

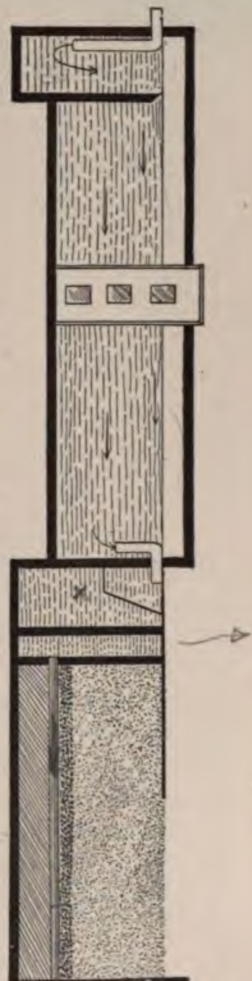


FIG. 45.—Section of septic tank and filter.

The Emscher Tank.—The Emscher tank consists of two cylinders, one smaller than the other, and placed in-

side the larger cylinder. The bottom of the larger cylinder is conical in shape, and the sludge is collected at the bottom of the tank, where it is protected from the stream of sewage which is passing through the tank (Fig. 45*a*). The gases which are formed by the action of the anaërobic bacteria on the organic matter in the sewage pass up through the smaller, inner cylinder, and escape into the air. This prevents them from coming in contact with the sewage flowing through the tank.

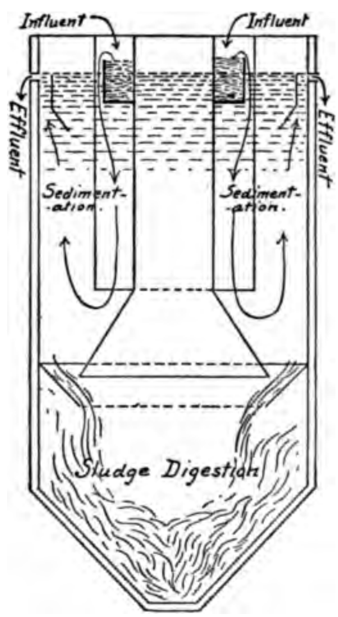


FIG. 45*a*.—Emscher tank.

Sprinkling Filters.—Sprinkling filters are the outcome of experiments with gravel filters at the Lawrence Experiment Station,[1] but the experiments of Mr. Joseph Corbett, borough engineer of Salford, England, have brought this method of sewage purification into prominence in England. The filters are constructed of five feet of crushed stone resting on six inches of gravel, that is, gravel underdrains. The crushed stone employed varies in size from 0.25 to 2 inches in diameter.

The sewage is applied intermittently to the surface of the filter in the form of a spray. This gives opportunity for the sewage to become aërated. Satisfactory results are obtained when the sewage contains about 80 per cent. of the amount of air required to saturate it. Sewage may be applied to filters of this character at the rate of 2,000,000 gallons per acre per day and obtain an effluent that is not putrescible. The effluent will contain only about 10 per cent. of the applied bacteria, and will show

[1] *Special Report Mass. State Board of Health*, 1890, part 2, pp. 549 and 565.

a reduction of the organic matter and its conversion into nitrates and nitrites through the agency of the nitrifying bacteria.

During 1904–05 Mr. George A. Johnson conducted extensive investigations upon the serviceability of different modern methods of sewage purification at Columbus, Ohio. The methods of purification tested in these investigations were: sedimentation, precipitation, septic tank, filtration through sand filters, contact filters, and sprinkling filters.

The process which was recommended to the city of Columbus as being the most satisfactory is that of the sprinkling filters, preceded by the preliminary clarification of the sewage in settling basins:

"1. Preliminary clarification of the sewage in basins holding on an average about an eight-hour flow and operated on the basis of the septic treatment.

"2. Purification of the septic effluent to a non-putrescible state by sprinkling filters at an average rate of 2,000,000 gallons per acre daily.

"3. Final clarification of the effluent of the sprinkling filters in basins holding an average flow of about two hours."

At the Sewage Experiment Station in Philadelphia the efficiency of the sprinkling filter in the purification of sewage was studied in detail. With filters exposed to the weather and receiving sewage "partially settled" the maximum rate obtained was 250,000,000 gallons per acre per day. With a filter protected from the weather a rate of three and one-tenth million gallons was used. The filters were constructed of trap-rock, one to three inches in size, in beds ranging from six to nine feet in depth. The bacterial efficiency of the sprinkling filters, when operated at a rate between 2,500,000 and 3,000,000 gallons per acre per day, was 400,000 per c.c., representing a reduction of 86 per cent.

The degree of purification, which it is aimed to secure in the modern systems of sewage purification, is such that the effluent shall not be putrescible and give rise to no

perceptible pollution of the body of water into which the effluent is allowed to flow. The amount of reduction of the organic matter in the sewage may vary in the effluent of different systems, depending upon the extent to which it is diluted by the body of water into which it is discharged and the use of such water at points near by. As the sprinkling-filter effluent contains large numbers of the sewage bacteria, it is at times advisable to treat this effluent with hypochlorites in order to disinfect it.

Since 1859 the city of Birmingham, England, has been studying in a practical way various methods of sewage purification, beginning with sedimentation, chemical precipitation, filtration, septic tank treatment, and finally purification by means of sprinkling filters. They have found that the latter method is far cheaper and more satisfactory than any other method heretofore employed, and have displaced all other methods by the sprinkling filters.

Removal of Sewage by Liernur System.—The satisfactory disposal of sewage is influenced directly by the fact whether the removal is by the separate or combined system. In the separate system of removal two sets of pipes are provided, one set for the household sewage, and another for the storm-water. This simplifies the purification process to a considerable extent. When the separate system of removal is employed some provision must be made for either flushing out the pipes carrying the household sewage, such as a flushing tank at the head of each branch sewer, or one of the methods of "air removal" may be employed. The method of air removal in more common use is what is known as the Liernur system. In this system there are two sets of pipes, the one set containing air only, and by the production of a partial vacuum in this set of pipes the sewage is extracted from the drain pipes. The system is so arranged that the discharges from each house are delivered into an air-tight metal reservoir, from which they are in turn drawn by suction into larger collecting tanks, these lat-

ter delivering the matter into a stream or into the disposal works. The main collecting tanks, receiving the sewage from the different branches, are at the lowest point of the district drained. A powerful suction pump produces a vacuum in the system, and once a day the entire system is exhausted. Each branch drain and reservoir is extracted in turn by closing off the rest of the system by means of valves; and finally the main collecting tanks are extracted. The entire operation is the work of one man, who makes the tour of the system, his only labor being the opening and closing of valves. There is nothing to give offence to the senses in this system, as all the tanks are underground and the valves are operated from connections at the surface of the ground. Owing to the manner in which the material is collected, its conversion into fertilizer is commercially possible, so as to yield a considerable revenue. At Trouville, France, where the population during the season reaches 20,000, it is estimated that the receipts from the sale of the poudrette will furnish a material income over and above the operating expenses. This system of air extraction is especially adapted for places in which the sewers lie too low to discharge directly into streams.

The Liernur system of extraction has been in operation for more than twenty-five years in Amsterdam and Leyden, and its success in these older installations has led to its introduction into other cities. The latest application of the method has recently been completed at the watering-place Trouville, France.

Commercial Value of Sewage.— Many scientists have attempted, by chemical analysis, to demonstrate the commercial value of the constituents of sewage as fertilizer. One investigator has estimated the yearly solid and liquid excreta of an adult person to yield 7.44 kilograms, an amount sufficient to fertilize about 365 kilograms of wheat, rye, or oats, or about 410 kilograms of barley; equivalent to 34 kilograms of Peruvian guana. Several scientists have estimated the manurial

value of London sewage to range from 3⅓ to 5 cents per ton, having an annual value of 14,000,000 to 20,000,000 dollars. It does not matter, however, what the intrinsic value may be of the manurial constituents of sewage, the nitrogen, phosphoric acid, and potash salts, so long as the conditions affecting supply and demand can neither be controlled nor regulated, its commercial value must remain very small—indeed, so small that sewage is much more likely to become a source of expense than one of revenue to any community. This has been the experience almost everywhere where attempts have been made to utilize sewage as fertilizer. The compressed sludge, the product of precipitation works, accumulates far more rapidly than it can be disposed of as fertilizer, and it frequently becomes a troublesome matter to dispose of it economically and satisfactorily. Even in such instances where sewage is utilized to irrigate cultivated fields it has at times been found detrimental to the crops raised, principally on account of the excessive quantities applied keeping the land constantly in a water-logged condition. This is said to have been the experience at Pullman, Ill.

CHAPTER VI.

GARBAGE DISPOSAL.

THE whole subject of the disposal of garbage and other household waste must be considered from an economic as well as from a sanitary standpoint, if satisfactory results are to be obtained. The question of utilization has heretofore been one of secondary consideration. If the cost of disposal can be reduced by utilizing a part or the whole of the refuse, then, for financial reasons, such utilization should be advocated.

The sanitary question seems to narrow itself down mainly to the prevention of all nuisance, no evidence having been obtained to indicate a serious effect upon the health of those engaged in the disposal of this refuse or in picking it over before final disposal.

In the southern States the term "garbage" is sometimes applied to dry refuse (Atlanta, Ga.), and to a mixture of dry refuse with animal and vegetable waste. In New England the word "swill" is more commonly used to designate kitchen waste, etc., while in Pennsylvania and one or two other States "slop" is the name applied to this material. The garbage is usually collected two or three times a week, but somewhat more frequently in densely populated districts, and during the hot weather daily collections should be made in cities. Ashes and dry refuse are usually collected once a week throughout the year. The collection is made either by private service, by contract, or by department employés.

The best information obtainable from analyses of garbage made in Europe shows the presence of 60 to 80 per cent. of moisture; rubbish, such as bottles, cans, rags, etc., about 7 per cent.; animal and vegetable dry matter, about 20 per cent.; and grease, from 2 to 4 per cent. The ashes

from the cremation of garbage constitute about 5 per cent. of the original mass. Mr. Westinghouse, of New York, estimates that garbage is composed of about 20 per cent. of carbon and 80 per cent. of water.

Collection and Removal of Garbage.—Where the garbage is removed either by the municipal authorities directly or by contractors, it should be collected in watertight receptacles supplied with lids, so as to prevent pollution of the air and soil at the point of collection. These receptacles should be emptied daily during the summer months, and every other day during the remainder of the year.

The carts or wagons employed in removing garbage should be constructed of metal, and so designed as to suit the special conditions. These carts should be supplied with lids, so that none of the material may be lost during removal, and also to limit the escape of objectionable odors during transit.

The following form of ordinance, recently transmitted to councils by the mayor of Philadelphia, is intended to reform the mode of handling garbage, the reforms being based upon the regulations in force in New York and Boston:

"Section 1. That it shall be unlawful for any person or persons to keep in his house or on his land any kitchen garbage or offal, unless the same is placed in water-tight vessels, free from ashes and other refuse matter (except food cans and food bottles).

"Section 2. No person shall place or keep in or near any building, ashes or cinders in such a manner as to cause fire, nor mix them with other substances, nor place or keep them except in metallic vessels so placed as to be easily removed.

"Section 3. All other refuse, such as paper, rags, excelsior, straw mattress, old clothing, pasteboard boxes, carpet, and other household waste, shall be kept in suitable vessels free from ashes and garbage, or in bundles, firmly fastened so as to prevent the rubbish from being

scattered in the handling, and protected from the weather until collected by the proper authority.

"Section 4. Ashes placed out for removal shall be moistened sufficiently to keep down dust while handling, and placed within 4 feet of the building-line, in vessels that will hold their contents without spilling; shall be placed out only on the day set for such removal, and taken in when emptied of their contents."

Disposal of Garbage.—There are a number of methods of disposal in use. This is partly due to the varying character of the refuse in different cities, as regards moisture, ashes, unburnt coal, and animal and vegetable matter, and partly to special circumstances which favor one or the other method. The system of disposing of garbage by reduction is used in about twelve cities in the United States. Cremation systems, by which garbage is destroyed by fire, are in use in a large number of cities. Eight cities dispose of their garbage by dumping it on land. This form of disposal costs from 11 to 39 cents per capita per year. In those cities which dump their garbage into the sea or into rivers the cost is from 36 to 75 cents per capita. In cities where the garbage is fed to animals the cost of collection and disposal varies from 28 to 37 cents per capita, and this probably takes into account the revenue which the contractor derives from the sale of this material. In smaller cities the cost of disposal by feeding to animals is sometimes as low as 9 cents per capita. The cost of disposal by reduction processes varies from 15 to 67 cents per capita. The cost of disposal by cremation is found to vary from 6 to 10 cents per capita in medium-sized cities, and in one small city a cost of 20 cents per capita is given.

Several years ago, New York City made a contract with the New York Sanitary Utilization Company for the disposal of garbage, the price being about $90,000 per annum. It contemplates the treating of the garbage of the entire city by steam, sterilizing it, and then, by

great pressure, separating the water and grease from the residue (called "tankage"), which is salable as fertilizer. Recently, Mr. Westinghouse made the suggestion that the garbage of New York be utilized in the manufacture of gas to be used for fuel purposes. He estimates that New York produces about 509,000 kilograms of garbage annually. Dr. Hutchinson estimates that 450 grams of this refuse have a maximum theoretical heating value of approximately 2000 calories, and that if all of this energy could be recovered in the form of gas it would require 3.85 kilograms of refuse per unit (kilowatt-hour) of electrical energy, and that "a consideration of the elementary principles involved shows a probable relation of 6.8 kilograms of refuse per unit (kilowatt-hour) in comparison with 11.3 kilograms, deduced from extensive tests with steam." These suggestions are of the greatest financial as well as sanitary importance, and seem to offer something which will not only favor the more systematic collection of garbage, but also its disposal to the financial advantage of the community.

Where the municipal authorities fail to provide the necessary system for the removal and disposal of garbage the novel method of disposing, introduced several years ago, may be adopted by the individual householder. This is domestic disposal in a special apparatus attached to the kitchen range. It consists of a perforated sheet-iron basket, with a tight bottom and a capacity of two to three liters. It is inserted into an expanded section of the stove-pipe, a short distance above the kitchen range, and allows the hot air and smoke to pass on all sides of the basket. It is easily withdrawn from its position and replaced with one hand. The garbage is placed into the basket as fast as it accumulates, and the contents are removed once a day. It dries to charcoal without burning, and becomes an excellent fuel for kindling the fire in the morning. It does not impair the use of the stove, nor interfere with the draught, causes no odors, and does not require any extra fuel.

For hotels, hospitals, or other public institutions something of greater capacity must be provided for the disposal of the garbage. To meet this demand a portable furnace has been devised, occupying about one-third of a square meter of space, with an independent chimney connection, which will destroy the waste in quantities of nearly a barrel at once. This apparatus has a garbage receptacle or retort of cast iron, cylindrical in form, with a cast-iron grate at the bottom. This retort is suspended 30 to 40 centimeters above the fire pot in the furnace, and the whole is encased in a jacket of heavy sheet iron. In operating, the retort is filled with garbage introduced through the charging door, a moderate fire is started, and the process of cremation begins. A simple arrangement of air jets, automatically actuated by the natural draught of the chimney, exhausts all the smoke and odors of the burning garbage from the retort and carries them down and through the furnace fire, so that nothing but the thoroughly purified and odorless gases, liberated by combustion, can escape into the chimney flue. Such an apparatus requires a comparatively small amount of fuel.

CHAPTER VII.

FOOD AND DIETING.

NOT only the health and strength of the body, but the intellectual and moral character as well, are dependent upon the nature and quantity of the food-supply. For this reason the question of food and diet is most complex, and the sanitary phase of it is not the most important one. It is, however, of sufficient importance to demand consideration in connection with general hygienic conditions, because of its relation to the welfare of man in general, and because of the dangers that arise from improper food materials, and also because of the influence upon health of excessive, as well as deficient, amounts of food.

The late Dr. Atwater defined food as follows: "Food is that which, when taken into the body, builds up its tissues and keeps them in repair, or which is consumed in the body to yield energy in the form of heat to keep it warm and create strength for its work."

Chemical Composition of the Body.—In order to understand the needs of the body in the shape of food to maintain its form and character, it will be necessary to consider briefly its chemical constituents. These are both organic and inorganic in their nature, composed of the following elements combined into a number of compounds: Hydrogen, oxygen, nitrogen, carbon, chlorin, fluorin, sulphur, silicon, phosphorus, potassium, sodium, lithium, calcium, magnesium, and iron.

The inorganic constituents of the body are water, which comprises about two-thirds of its weight; different gases, such as oxygen, hydrogen, nitrogen, carbon dioxid, ammonia, hydrogen sulphid, and marsh gas; salts, such as sodium chlorid, calcium phosphate (which forms more than one-half the substance of the bones), calcium carbonate and fluorid, sodium and potassium

sulphate, potassium and ammonium chlorid, sodium, potassium, and magnesum phosphate, and sodium carbonate and bicarbonate; hydrochloric acid; silica; and iron.

The organic constituents may be divided into the nitrogenous and non-nitrogenous bodies, of which the nitrogenous are the most numerous. They consist of the albuminous bodies, or proteids; the albuminoid substances; certain complex bodies, such as the ferments, and coloring-matters, the ammonia derivatives. The non-nitrogenous bodies consist of two groups, fats and carbohydrates.

All of these various elements and chemical combinations, constituting the composition of the body, must be supplied in the food-supply in order that it may perform its normal functions and obtain energy for all of man's activities in life. Under normal physiologic conditions the amount of material absorbed from the food is about equal to that which is thrown off by the excretory organs. During the period of growth the amount absorbed exceeds the amount excreted, while in most acute diseases the amount excreted is far in excess of the amount absorbed, and, consequently, the body wastes. The body increases or diminishes in weight proportionately as the amount of material absorbed from the food is greater or less than the amount excreted. A man of average weight and activity takes about 325 grams of dry solid matter and from 1500 to 2000 grams of water, while about 550 grams of oxygen are absorbed by the lungs per day. Of the solids taken, about 40 grams are eliminated by the intestines, and the remaining 285 grams by the other excretory organs. The oxygen taken in is also excreted by these organs, after having been utilized; the latent or potential energy of the food being converted into kinetic energy. The body loses in this way about one-twentieth of its weight daily, and this loss must be made up from the food ingested.

By latent or potential energy is meant the energy capable of performing work when called upon; such, for example, as resides in a suspended weight. By kinetic

energy is meant energy which is doing work; such as the force exerted by the weight in falling to the ground. Heidenhain calculated that four-fifths of the total energy of the body takes the form of heat. It may be stated, therefore, that the body is a machine for converting potential energy into kinetic energy. The potential energy is supplied by the food, and the metabolism of the body converts this into the kinetic energy of heat and mechanical power.

Potential Energy in Food.—The potential energy contained in any substance is determined by ascertaining the amount of heat that is produced by its complete combustion. The potential energy contained in any substance is expressed in calories. By a calorie is meant the amount of heat required to warm 1 gram of water 1 degree centigrade. This is the "small calorie," as distinguished from the "large calorie," which is equivalent to the amount of heat required to warm 1 kilogram of water 1 degree centigrade (kilogram-degrees). The large calorie is, therefore, 1000 times greater than the small calorie and is used when speaking of large quantities, and the smaller figure is used when it would be more convenient. The amount of heat given off by the human adult body per day is equal to the heat required to warm 2,500,000 grams, or 2500 kilograms, of water 1 degree centigrade, and this amount of heat is generated by the body each day from the food ingested. According to Konig, the more common food-stuffs have values as fuel as follows:

1 gram of dry meat yields	5103	calories.
1 gram of albumin yields	4998	"
1 gram of sugar yields	3227	"
1 gram of starch (arrowroot) yields	3912	"
1 gram of butter yields	7264	"
1 gram of suet yields	9096	"
1 gram of vegetable fibrin yields	6231	"
1 gram of casein (milk) yields	5785	"
1 gram of fibrin (blood) yields	5709	"
1 gram of peptone (Schuhardt) yields	5334	"
1 gram of glutein yields	5943	"
1 gram of chondrin yields	4909	"
1 gram of urea yields	2537	"

1 gram of Liebig's meat-extract yields	3206	calories.
1 gram of fat (extracted with cold ether) yields .	9686	"
1 gram of fresh rye bread yields	2727	"
1 gram of dry rye bread yields	4421	"
1 gram of fresh wheat bread yields	2807	"
1 gram of dry wheat bread yields	4302	"

When we compare the nutrients in respect to their fuel values with their capacities for yielding heat and mechanical power, a gram of lean meat or albumin of egg is just about equivalent to 1 gram of sugar or starch, and a little over 2 grams of either would be required to equal 1 gram of fat meat or butter. These are called isodynamic values. Compared with each other, 100 grams of animal albumin are isodynamic with 52 grams of fat, 114 grams of starch, or 129 grams of dextrose; 100 grams of fat are isodynamic with 243 grams of dry flesh or 225 grams of dry syntonin.

The food is utilized in the body for the following different purposes: To form the tissues and fluids of the body; to repair the waste in the tissues; it is stored up in the body for future consumption; it is consumed as fuel, its potential energy being transformed into heat, muscular or other forms of energy; or, in being consumed, it protects the tissues or other food from consumption.

The proteid nutrients form tissue, and also serve as fuel; the fats form fatty tissue, and also serve as fuel; the carbohydrates are transformed into fat and serve as fuel.

The mechanical energy obtainable from various articles of food is dependent upon the amount of potential energy stored up in the food, which is expressed in terms of calories, and the extent to which the processes of the body can liberate and apply this energy. For instance, a gram of albumin gives rise to a certain amount of heat when burned in oxygen; but in the body thorough oxidation does not take place, because some of the constituents of the albumin are given off incompletely oxidized in the form of urea. A gram of sugar, on the other hand, is generally completely oxidized, being con-

verted into carbon dioxid and water, and its actual energy in the body is equal to its theoretical energy. The mechanical energy obtainable from the transformation of albumin is arrived at by multiplying the number of grams of its several constituents by a number, determined by exact experiment, representing the amount of heat produced by the oxidation of 1 gram of carbohydrate, fat, or proteid to water, carbon dioxid, and urea.

According to Rubner, the average calorific value of proteid matter is 4124 calories—that is, 1 gram of proteid oxidized to urea yields 4124 gram-degrees (or 4.1 kilogram-degrees) of heat; 1 gram of fat yields 9321 calories (9.3 kilogram-degrees); and 1 gram of carbohydrate (starch) yields 4116 calories (4.1 kilogram-degrees). Applying these numbers to Voit's diet for a man of 70 kilos doing hard muscular work, we obtain in round numbers:

105 grams of assimilated proteid	× 4.1 =	430 kilogram-degrees.
56 grams of fat	× 9.3 =	520 "
500 grams of carbohydrate	× 4.1 =	2050 "
		3000 kilogram-degrees,

or 3,000,000 calories, as the potential energy of the food. This amount may be taken as the average required for a man. For women the amount is somewhat less than this, both absolutely and relatively. For children, though absolutely less, it is relatively greater.

Energy Derivable from Food.—In order to calculate how much mechanical work can be performed by, or is equal to, the potential energy expressed in calories, we must know the relation between heat and motion. According to Landois, the energy required to heat 1 gram of water 1 degree centigrade would raise a weight of 425.5 grams to a height of 1 meter; or 425.5 grams of water falling through 1 meter would raise the temperature of 1 gram of water 1 degree centigrade. The mechanical equivalent of the calorie is obtained by multiplying the calories by 425.5, and is expressed as a gram-meter. If we multiply the calorific value of the

alimentary principles by 425.5, we obtain the mechanical energy of 1 gram of each, as follows:

Proteids	4124 × 425.5 = 1754	meter-kilos.
Fats	9321 × 425.5 = 3966	"
Carbohydrates	4116 × 425.5 = 1751	"

In order to ascertain the mechanical energy contained in any diet we multiply the number of grams of each alimentary principle by the figures representing the mechanical energy of each. Taking the standard diet of Moleschott for a man performing moderate work we obtain the following results:

Proteids	145 × 1754 =	254,330
Fats	45 × 3966 =	193,470
Carbohydrates	605 × 1751 =	1,059,355
		1,507,155 meter-kilos.

According to Hueppe, the loss of heat from the body during work is as follows:

Loss through radiation and conduction	1789 large calories.
Loss through evaporation from the skin	384 large calories.
Loss through evaporation from the lungs	192 large calories.
Total	2365 large calories.
Loss of heat during rest	1500 large calories.
Excess during work	865 large calories.

He gives the following dietaries from which he estimates the amount of energy available for mechanical work:

Per 70 kilograms of body-weight.		Albumin.	Fat.	Carbohydrates.	Total calories per 70 kilograms of body-weight.	Calories per 1 kilogram of body-weight.
A. Complete rest. According to Hueppe.	The food contains—	65 grams.	30 grams.	300 grams.	——	——
	Having gross calories	(65 × 4.1) = 266.5	(30 × 9.3) = 279	(300 × 4.1) = 1230	1775.5	25.364
	Having pure calories.	(65 × 3.4) = 221	(30 × 8.3) = 249	(300 × 3.8) = 1140	1610.0	23.000
B. Medium work (mason, soldier in garrison). 1. According to Voit.	The food contains—	118 grams.	56 grams.	500 grams.	——	——
	Having gross calories	(118 × 4.1) = 483.8	(56 × 9.3) = 520.8	(500 × 4.1) = 2050	3054.6	43.637
	Having pure calories.	(118 × 3.4) = 401.2	(56 × 8.3) = 464.8	(500 × 3.8) = 1900	2766.0	39.514
2. According to Hirschfeld.	The food contains—	100 grams.	110 grams.	400 grams.	——	——
	Having gross calories	(100 × 4.1) = 410	(110 × 9.3) = 1023	(400 × 4.1) = 1640	3073.0	43.900
	Having pure calories.	(100 × 3.4) = 340	(110 × 8.3) = 913	(400 × 3.8) = 1520	2773.0	41.700
C. Japanese, usual work, and vegetable diet. According to Scheube.	The food contains—	126 grams.	16 grams.	633 grams.	——	——
	Having gross calories	(126 × 4.1) = 516.6	(16 × 9.3) = 148.8	(633 × 4.1) = 2595.3	3260.7	46.581
	Having pure calories.	(126 × 3.4) = 378.0	(16 × 8.3) = 136.0	(633 × 3.8) = 2405.4	2919.4	41.700
D. German laborer at hard work (smith; soldier in the field). According to Voit.	The food contains—	145 grams.	67 grams.	500 grams.	——	——
	Having gross calories	(145 × 4.1) = 594.5	(67 × 9.3) = 623.1	(500 × 4.1) = 2050	3267.6	46.680
	Having pure calories.	(145 × 3.4) = 493.0	(67 × 8.3) = 556.1	(500 × 3.8) = 1900	2949.1	42.130

The available energy for mechanical work in the above diets (the mechanical equivalent = 425), after deducting the excess of heat lost during work, is as follows :

B_1 . . 1266 – 865 = 401 calories × 425 = 170,425 kgm. = 14.5 per cent.
B_2 . . 1273 – 865 = 408 calories × 425 = 173,400 kgm. = 15.0 "
C . . 1419 – 865 = 554 calories × 425 = 235,450 kgm. = 19.0 "
D . . 1449 – 865 = 584 calories × 425 = 248,200 kgm. = 20.0 "

The maximum day's work of eight hours, tested on the ergograph, ranges from 200,000 to 250,000 meter-kilos.

The mechanical energy present in an ordinary diet may, therefore, be estimated at 1,250,000 meter-kilos. The work and heat of the body use up the following amounts, according to De Chaumont :

Work of circulation	75,000	meter-kilos.
Work of respiration	12,000	"
Calorific work	781,000	"
External work (93,000 kgm.)	465,000	"
	1,333,000	meter-kilos.

This total is in excess of the total energy contained in the standard diet, but this is unavoidable, according to Davies, "in calculations of such an approximate nature as the present one ; the important point as regards dieting is the proportion that should exist between the different objects for which the total energy is supplied."

The following may be taken as an approximate basis for the calculation of diets according to size and work :

Proximate.	For subsistence.	For work of 93,000 meter-kilos per diem.	For work of 100,000 meter-kilos per diem.
Aliment.	Grams per kilogram of body-weight.	Grams per kilogram of body-weight.	Grams per kilogram of body-weight.
Proteids	1.044	1.903	2.06
Fats	0.412	1.132	1.32
Carbohydrates	5.000	5.937	6.38
Salts	0.163	0.380	0.47
Total	6.619	9.352	10.23

Dietary Standards (Atwater).

	European standards for daily dietaries.	Nutrients. Protein.	Fats.	Carbohydrates.	Fuel value.	Nutritive ratio.
		Grams.	Grams.	Grams.	Calories.	
1	Children, one to two years, average	30.0	40.0	85.0	765	1 : 5.7
2	Children, two to six " "	60.0	45.0	220.0	1420	1 : 5.3
3	Children, six to fifteen " "	85.0	50.0	360.0	2040	1 : 5.6
4	Aged woman	90.0	55.0	285.0	1860	1 : 4.7
5	Aged man	110.0	75.0	385.0	2475	1 : 5.0
6	Woman at moderate work	100.0	50.0	440.0	2425	1 : 5.4
7	Man " " " (Voit)	130.0	60.0	550.0	3055	1 : 5.3
8	Man " hard " (Voit)	160.0	110.0	495.0	3370	1 : 4.7
9	Man " moderate " (Moleschott)	145.0	45.0	605.0	3160	1 : 4.9
10	Man " " (Wolff)	140.0	40.0	595.0	3030	1 : 4.9
11	Subsistence diet (Playfair)	65.0	15.0	375.0	1760	1 : 6.5
12	Diet in quietude (Playfair)	80.0	30.0	375.0	1950	1 : 5.7
13	Adults in full health (Playfair)	130.0	55.0	185.0	3140	1 : 5.4
14	Active laborers (Playfair)	170.0	80.0	625.0	3630	1 : 4.7
15	Hard-worked laborers (Playfair)	205.0	80.0	625.0	3750	1 : 3.9
	American Standards.					
1	Woman with light muscular exercise	90			2400	1 : 5.5
2	Woman with moderate " exercise	100			2700	1 : 5.6
3	Man without muscular work	112			3000	1 : 5.5
4	Man with light " "					
5	Man with moderate muscular work	125			3500	1 : 5.8
6	Man with hard " "	150			4500	1 : 6.3

The figures of the foregoing tables represent the amounts of nutrients which different investigators have estimated to be proper for the daily food of different classes. The minimum standard of daily diet, approximately calculated, may be given as follows:[1]

Minimum Standard of Daily Diet.

	Albumin.	Fat.	Carbohydrates.
	Grams.	Grams.	Grams.
Child up to one and one-half years of age	20–36	30–45	60–90
Child from six to fifteen years	70–80	37–50	250–400
Man, at moderate labor	118	56	500
Woman, at moderate labor	92	44	400
Man, at severe labor	120–145	100	500
Man of advanced age	100	68	350
Woman of advanced age	80	20	260

[1] *Gesundheitsbüchlein*, Berlin, 1896, Imperial Board of Health.

Shortly after the commencement of the European War the German Government called into service a committee of scientific experts, known as the Eltzbacher Commission, to study the food problem and devise defensive measures for the empire. This commission based its calculations of the needs of the people with regard to the protein of the food on data presented in the following table. The amounts adopted by the commission are higher than the figures promulgated by Chittenden as representing the physiologic needs of the human body, but lower than A. E. Taylor's calculations of the physiologic needs of man as based on war-time conditions:

	Protein needs.		Protein needs.	
	Per capita.	Man ration.	Per capita.	Man ration.
Eltzbacher Commission.[1]	2.30 gm.	2.83 gm.	2380	3000
A. E. Taylor	2.15 gm.	2.50 gm.	2510	3300
Chittenden	1.50 gm.	1.80 gm.	2030	2600

Graham Lusk points[2] out that the Eltzbacher Commission failed to take into account the increased food requirements of growing children.

According to Hueppe, the following reductions must be made because all of the nutritive materials in the food ingested are not absorbed: In general, 1.5 per cent. of the albumin is not absorbed. Of the fat of pork, only 98 per cent. is absorbed; of beef, 90 per cent. Mixed with meat the digestibility of animal fats averages 83 per cent. Beef, with a content of 20.91 per cent. of nitrogenous matter and 5.19 per cent. of ether extract, has a gross

[1] *Saturday Evening Post*, Feb. 17th, 24, and March 3, 1917.
[2] *Science*, April 13, 1917.

value as follows: 100 gm. = 20.91 × 4124 + 5.19 × 9321 = 86.232 + 48.376 = 134 calories. If we assume that the digestibility of the albumin is 97.5 per cent., and that of the fat 83 per cent., then the true value is as follows: 100 gm. = 86.232 × 0.975 + 48.376 × 0.83 = 84.076 + 40.152 = 124 calories.

This calculation holds true for meat free from bones, but in the calculation of a general dietary a reduction of 15 per cent. must be made for bones. One hundred grams of commercial meat with 15 per cent. of bones contain 17.78 per cent. of nitrogenous matter and 4.41 per cent. of ether extract; and calculated as above, possess a true value of 105 calories.

According to von Reckenberg, the digestibility of meat per 100 grams of substance is as follows:

	Nitrogenous substance. (Albumin.)		Ether extract. (Fat.)		Physiologic energy. without | with reference to digestibility.	
	Content. gm.	Digestible. gm.	Content. gm.	Digestible. gm.	Gross value. Calories.	True value. Calories.
Beef. Medium fat, without bones	20.91	20.39	5.19	4.31	132 [1]	122
Beef. Medium fat, with 15 per cent. of bones	17.78	17.33	4.41	3.66	112	104
Pork. Fat, without bones	14.54	14.18	37.34	30.99	409	348
Pork. Fat, with 10 per cent. of bones	13.09	12.76	33.61	27.89	368	313
A herring, 135 gm., 37 per cent. waste	16.07	15.67	14.36	11.92	199	174
Fat, smoked	2.6	2.54	77.80	64.57	742	617
Lard, rendered	0.26	0.25	99.04	94.04	934	887

The digestibility of the nitrogenous substance can be assumed to be the same for all kinds of meat. One gram of ether extract represents 9415 calories in pork, the bone refuse being reckoned as 10 per cent. Rendered swine and beef fat, as well as the fat of fish and geese, may be

[1] In these calculations albumin is represented as 4003, and fat at 9320 calories.

calculated as in the case of pork fat, while the fat of other animals must be calculated as in the case of beef. In smoked fat 1 gram of ether extract represents 9400 calories, because the ether extract does not contain pure fat.

Nutritive Value and Cost of Food.—The following tables are based on the tables in the Appendix of "Foods: Nutritive Value and Cost," by Prof. Atwater, *Farmer's Bulletin* No. 23, issued by the U. S. Department of Agriculture. In each of the tables the fuel value has been expressed in calories of the metric system instead of the amounts contained in the tables. The weight of the food materials has been expressed in grams instead of in ounces and pounds. "Table B gives the proportions of ingredients in a number of materials as found by analysis of specimens collected for the most part in New York and New England markets."

TABLE A.—*Amounts of Nutrients furnished for 25 cents in Food Materials at Ordinary Prices.*

Food materials as purchased.	Prices per ½ kg. (1 lb.)	Twenty-five cents will pay for—					Fuel value.
		Total food materials.	Nutrients.				
			Total.	Protein.	Fats.	Carbo-hydrat's	
		Grams.	Grams.	Grams.	Grams.	Grams.	Calories.
Beef, sirloin	25	500	155.0	75.0	80.0	. .	970
Beef, round	16	780	235.0	140.0	95.0	. .	1335
Beef, neck	8	1565	465.0	245.0	220.0	. .	2755
Mutton, leg	20	625	190.0	95.0	95.0	. .	1170
Ham, smoked	16	780	385.0	115.0	270.0	. .	2705
Salt pork	10	1250	1045.0	10.0	1035.0	. .	8775
Codfish, fresh	10	1250	135.0	. .	. .	. .	510
Codfish, dried salt	8	1565	255.0	250.0	5.0	. .	985
Mackerel, salt	10	1250	370.0	185.0	185.0	. .	2275
Oysters, 25 cents per quart	12.5	1000	120.0	65.0	15.0	40.0	520
Eggs, 25 cents per dozen	14.7	850	190.0	105.0	85.0	. .	1115
Milk, 8 cents per quart	4	3125	385.0	115.0	125.0	145.0	2030
Cheese, whole milk	15	835	545.0	235.0	295.0	15.0	3455
Cheese, skimmed milk	10	1250	675.0	480.0	85.0	110.0	2910
Butter, 25 cents per pound	25	500	430.0	5.0	425.0	. .	3615
Sugar, 5 cents per pound	5	2500	2445.0	. .	. .	2445.0	9100
Wheat flour	2.5	5000	4350.0	550.0	55.0	3745.0	16,450
Wheat bread	5	2500	1670.0	220.0	40.0	1410.0	6400
Oatmeal	5	2500	2260.0	370.0	180.0	1710.0	9225
Beans	5	2500	2110.0	580.0	50.0	1480.0	8075
Potatoes, 60 cents per bushel	1	12,500	2135.0	225.0	10.0	1900.0	8000

TABLE B.—*Composition of Different Food Materials.*

FOOD MATERIALS.	Refuse (bones, skin, shell, etc.).	Edible portion.						
			Nutrients.					
		Water.	Total.	Protein.	Fat.	Carbohydrates.	Mineral matters.	Fuel value of 500 grams.
Animal foods as purchased.								
Beef:	–	–	–	–	–	–	–	Cal.
Neck	20	49.6	30.4	15.6	14	. .	.8	880
Shoulder	12.6	55.8	31.6	17	13.7	. .	.9	895
Chuck rib	14.6	49.5	35.9	15	20.1	. .	.8	1125
Rib	21	38.2	40.8	12.2	27.9	. .	.7	1405
Sirloin	19.5	48.3	32.2	15	16.4	. .	.8	970
Round steak	7.8	60.9	31.3	18	12.3	. .	1	855
Side, without kidney fat	19.2	44.3	36.5	13.9	21.8	. .	.8	1180
Rump, corned	5	70.8	24.2	16.7	5.1	. .	2.4	525
Flank, corned	12.1	43.7	44.2	12.4	29.2	. .	2.6	1460
Veal, shoulder	17.9	56.7	25.4	16.6	7.9	. .	.9	640
Mutton:								
Shoulder	16.3	49	34.7	15.1	18.8	. .	.8	1075
Leg	18.1	50.6	31.3	15	15.6	. .	.7	935
Loin	15.8	41.5	42.7	12.6	29.5	. .	.6	1480
Side, without kidney fat	17.3	44.2	38.5	14	23.7	. .	.8	1260
Pork:								
Shoulder roast, fresh	14.6	43	42.4	13.6	28	. .	.8	1435
Ham, salted, smoked	11.4	36.8	51.8	14.8	34.6	. .	2.4	1735
Chicken	38.2	44.6	17.2	15.1	1.2	. .	.9	330
Turkey	32.4	44.7	22.9	16.1	5.9	. .	.9	550
Eggs, in shell	13.7	63.1	23.2	12.1	10.2	. .	.9	655
Fish, etc.:								
Flounder, whole	66.8	27.2	6	5.2	.3	. .	.5	110
Bluefish, dressed	48.6	43	11.1	9.8	.6	. .	.7	210
Codfish, dressed	29.9	58.5	11.6	10.6	.2	. .	.8	205
Shad, whole	50.1	35.2	14.7	9.2	4.8	. .	.7	375
Mackerel, whole	44.8	40.4	15	10	4.3	. .	.7	365
Halibut, dressed	17.7	61.9	20.4	15.1	4.4	. .	.9	465
Salmon, whole	35.3	40.6	24.1	14.3	8.8	. .	1	635
Salted codfish	42.1	40.5	17.6	16	.4	. .	1.2	315
Smoked herring	50.9	19.2	29.9	20.2	8.8	. .	.9	745
Salted mackerel	40.4	28.1	31.5	14.7	15.1	. .	1.7	910
Canned salmon	4.9	59.3	35.8	19.3	15.3	. .	1.2	1005
Lobsters	62.1	31	6.9	5.5	.7	.1	.6	135
Oysters	82.3	15.4	2.3	1.1	.2	.6	.4	40
Animal foods, edible portion.								
Beef:								
Neck	. .	62	38	19.5	17.5	. .	1	1100
Shoulder	. .	63.9	36.1	19.5	15.6	. .	1	1020
Chuck rib	. .	58	42	17.6	23.5	. .	.9	1320
Rib	. .	48.1	51.9	15.4	35.6	. .	.9	1790
Sirloin	. .	60	40	18.5	20.5	. .	1	1210
Round	. .	68.2	31.8	20.5	10.1	. .	1.2	805
Side, without kidney fat	. .	54.8	45.2	17.2	27.1	. .	.9	1465
Rump, corned	. .	58.1	41.9	13.3	26.6	. .	2	1370
Flank, corned	. .	49.8	50.2	14.2	33	. .	3	1655
Veal, shoulder	. .	68.8	31.2	20.2	9.8	. .	1.2	790
Mutton:								
Shoulder	. .	58.6	41.4	18.1	22.4	. .	.9	1280
Leg	. .	61.8	38.2	18.3	19	. .	.9	1140
Loin	. .	49.3	50.7	15	35	. .	.7	1755
Side, without kidney fat	. .	53.5	46.5	16.9	28.7	. .	.9	1525
Pork:								
Shoulder roast, fresh	. .	50.3	49.7	16	32.8	. .	.9	1680
Ham, salted, smoked	. .	41.5	58.5	16.7	39.1	. .	2.7	1960
Fat, salted	. .	12.1	87.9	.9	82.8	. .	4.2	3510
Sausage:								
Pork	. .	41.5	58.8	13.8	42.8	. .	2.3	2065
Bologna	. .	62.4	37.6	18.8	15.8	. .	.3	1015
Chicken	. .	72.2	27.8	24.4	2	. .	1.4	540

TABLE B (*continued*).

Food Materials.	Refuse (bones, skin, shell, etc.).	Edible portion.						
			Nutrients.					
		Water.	Total.	Protein.	Fat.	Carbohydrates.	Mineral matters.	Fuel value of 500 grams.
Turkey	. .	66.2	33.8	23.9	8.7	. .	1.2	810
Eggs	. .	73.8	26.2	14.9	10.5	. .	.8	721
Milk	. .	87	13	3.6	4	4.7	.7	325
Butter	. .	10.5	89	1	85	.5	3	3615
Oleomargarin	. .	11	89.5	.6	85	.4	3	3605
Cheese:								
Full cream	. .	30.2	69.8	28.3	35.5	1.8	4.2	2070
Skimmed milk	. .	41.3	58.7	38.4	6.8	8.9	4.6	1165
Fish:								
Flounder	. .	84.2	15.8	13.8	.7	. .	1.3	285
Haddock	. .	81.7	18.3	16.8	.3	. .	1.2	325
Codfish	. .	82.6	17.4	15.8	.4	. .	1.2	310
Shad	. .	70.6	29.4	18.6	9.5	. .	1.3	745
Mackerel	. .	73.4	26.6	18.2	7.1	. .	1.3	640
Halibut	. .	75.4	24.6	18.3	5.2	. .	1.1	560
Salmon	. .	63.6	36.4	21.6	13.4	. .	1.4	965
Salted cod	. .	53.6	. .	21.4	.3	. .	1.6	410
Herring, salted	. .	34.6	. .	36.4	15.8	. .	1.5	1345
Mackerel, salted	. .	43.4	. .	17.3	26.4	. .	2.6	1860
Oysters	. .	87.1	12.9	6	1.2	3.7	2	1230
Vegetable foods.								
Wheat flour	. .	12.5	87.5	11	1.1	74.9	.5	1645
Graham flour (wheat)	. .	13.1	86.9	11.7	1.7	71.7	1.8	1625
Rye flour	. .	13.1	86.9	6.7	.8	78.7	.7	1625
Buckwheat flour	. .	14.6	85.4	6.9	1.4	76.1	1	1605
Oatmeal	. .	7.6	92.4	15.1	7.1	68.2	2	1850
Cornmeal	. .	15	85	19.2	3.8	70.1	1.4	1645
Rice	. .	12.4	87.6	7.4	.4	79.4	.4	1630
Peas	. .	12.3	87.7	26.7	1.7	56.4	2.9	1565
Beans	. .	12.6	87.4	23.1	2	59.2	3.1	1615
Potatoes	. .	78.9	21.1	2.1	.1	17.9	1	375
Sweet potatoes	. .	71.1	28.9	1.5	.4	26	1	530
Turnips	. .	89.4	10.6	1.2	.2	8.2	1	185
Carrots	. .	88.6	11.4	1.1	.4	8.9	1	200
Onions	. .	87.6	12.4	1.4	.3	10.1	.6	225
String beans	. .	87.2	12.8	2.2	.4	9.4	.8	235
Green peas	. .	78.1	21.9	4.4	.6	16	.9	405
Green corn	. .	81.3	18.7	2.8	1.1	13.2	.6	345
Tomatoes	. .	96	4	.8	.4	2.5	.3	80
Cabbage	. .	91.9	8.1	2.1	.3	5.5	1.1	155
Apples	. .	83.2	16.8	.2	.4	15.9	.3	315
Sugar, granulated	. .	2	98	. .	. .	97	.2	1820
Molasses	. .	24.6	75.4	. .	. .	73.1	2.3	1360
White bread (wheat)	. .	32.3	67.7	8.8	1.7	56.3	.9	1280
Boston crackers	. .	8.3	91.7	10.7	9.9	68.7	2.4	1895

Digestibility of Foods.—In general, the animal foods are somewhat more digestible than the vegetable foods. The proteid matter of ordinary meats, for instance, is practically all digested when eaten in moderate quantities by healthy persons (97.5 per cent.); but the same person might digest only nine-tenths of the proteid matter of wheat, and not more than three-fourths of that of potatoes. The fat of meats is less completely digested.

The sugar and starch of vegetables, when they are properly cooked, are very easily and completely digested.

According to the experiments of Dr. Beaumont on Alexis St. Martin, the digestibility of different food substances ranges itself in the following order: "Rice, tripe, whipped eggs, sago, tapioca, barley, boiled milk, raw eggs, lamb, parsnips, roasted and baked potatoes, and fricasseed chicken are most easily digested in the order given—the rice disappearing from the stomach in one hour, and the fricasseed chicken in two and three-fourths hours. Beef, mutton, pork, oysters, butter, bread, veal, boiled and roasted fowls are rather less digestible, roast beef disappearing from the stomach in three hours, and roast fowl in four hours. Salted beef and pork disappear in four and a quarter hours."

The following list (Chambers) shows the relative digestibility of different articles of food: "Roast mutton, sweetbread, boiled chicken, venison, soft-boiled eggs, new toasted cheese, roast fowl, turkey, partridge and pheasant, lamb, wild duck, oysters, periwinkles, omelette, tripe, boiled sole, haddock, skate, trout, perch, roast beef, boiled beef, rump steak, roast veal, boiled veal, rabbit, salmon, mackerel, herring, pilchard, sprat, hard-boiled and fried eggs, pigeon, hare, duck, goose, fried fish, roast and boiled pork, heart, liver, kidneys, lobster, salted fish, crab."

The digestibility of food depends upon the nature of the food substance, its hardness and cohesion, and on its chemical nature, as well as on the degree to which it is altered by cooking. It is also dependent upon the individual characteristic of each person, the digestive power of the organs of digestion. The admixture of different classes of foods also aids digestion; some of the accessory foods probably causing an increased flow of the digestive fluids. The degree of fineness of the food and, consequently, the thoroughness of mastication are important factors in favoring digestion. The amount of food taken at a time also plays an important influence in digestion.

Composition of Foods.—The ordinary food materials consist of refuse matter, such as the bones of meat and fish, the shells of shellfish, the skin of potatoes, and the bran of wheat; and of proteid matter, fats, carbohydrates, and salts.

Prof. Atwater, in his reports on the chemical composition of food materials, uses the term "protein," which "includes nominally the total nitrogenous substance of animal and vegetable food materials, exclusive of the so-called nitrogenous fats." The term "proteid," as used in the same reports, "includes (1) the simple proteids, *e. g.*, albuminoids, globulins and their derivatives, such as acid and alkali albumins, coagulated proteids, proteoses, and peptones; (2) the so-called combined or compound proteids; (3) the so-called gelatinoids (sometimes called 'glutinoids'), which are characteristic of animal connective tissue." The term "albuminoids" is used as a "collective designation of the substances of the first two groups, though many apply it to all three of these groups. Of late a number of investigators and writers have employed the term as a special designation for compounds of the third class." The term "non-proteid" is "used synonymously with the term non-albuminoid," and includes nitrogenous animal and vegetable compounds of simpler constitution than the proteids. The most important animal compounds of this class are the so-called "nitrogenous extractives" of muscular and connective tissue, such as creatin, creatinin, xanthin, hypoxanthin, and allied cleavage products of the proteids. The non-proteid nitrogenous compounds in vegetable foods consist of amids and amido-acids, of which asparagin and aspartic acid are familiar examples.

The total nitrogenous substance is estimated by determining the amount of nitrogen present and multiplying the product by the factor 6.25.

The fats include the true vegetable and animal fats, such as the fat of fat meat, the fat of milk, olive oil, cottonseed oil, etc., and various other substances, such

as the fatty acids, lecithins (nitrogenous fats), and the chlorophyls. The fats contain about 75 per cent. of carbon. Under carbohydrates are included the different sugars, starches, gums, and cellulose, or woody fiber. These substances are found most plentifully in the cereals, as wheat, oats, corn, rye, and barley, in the Leguminosæ, and in the different roots, tubers, and green vegetables.

Under mineral foods are included water, phosphates, sulphates, chlorids, and other salts of potassium, sodium, magnesium, and other metallic elements. Of these, sodium chlorid is the most important, its presence exciting assimilative changes and assisting in the secretion of many of the digestive fluids, especially of the gastric juice; and so necessary is it to the organism that when it is supplied in insufficient quantity it is retained by the tissues and not excreted. When deprived of it animals lose in weight and activity. The potassium salts are also indispensable, acting as exciters of the nervous system and increasing the cardiac pulsations. The phosphates are of importance because of the large amounts required to maintain the normal condition of the bones.

Functions of the Alimentary Principles of Food.—The various nitrogenous substances in foods serve the following purposes when taken into the system: Formation and repair of the tissues and fluids of the body; the regulation of the absorption and utilization of oxygen; and they serve as regulators of digestion and assimilation, especially with reference to the gelatin group.

Of the non-nitrogenous substances in foods, the fats serve to supply fatty tissues and as nutrition to the nervous system. They also supply energy and animal heat by oxidation. The carbohydrates also serve to supply energy and animal heat by oxidation, and they are converted into fat by deoxidation, and stored in the body for future use. The vegetable acids serve to maintain the alkalinity of the blood by conversion into car-

bonates, and to furnish a small amount of energy or animal heat by oxidation.

The mineral matters of food serve to support the bony skeleton, supply hydrochloric acid for digestion, also as regulators of energy and nutrition.

In addition to the four alimentary principles in food, several groups of substances, which are not included in this classification, must also be mentioned. These are the condiments and beverages. The condiments are of importance because they serve to give flavor to food, and stimulate secretion and digestion, though they have but little direct influence in forming tissue or in supplying energy and heat.

Besides the alimentary principles contained in food there are one or more constituents, the exact nature of which is not known, called the *vitamins,* but the absence of which leads to defective nutrition. Beriberi, scurvy, and probably pellagra are conditions of malnutrition which are traceable to the absence of certain principles in the daily dietary. It is apparent that each of these conditions is due to the absence of a different substance. It is of the greatest importance to avoid too constant sameness in the diet. A mixed diet which is varied from day to day and from season to season is the best safeguard against malnutrition.

Water as Food.—Since water forms about two-thirds of the weight of the body, a great deal of fluid must be taken into the system in order to balance the constant loss through the excretions. This fluid is in part supplied by the food as usually prepared, but a large proportion must be supplied directly as water or in the form of some beverage, as tea, coffee, milk, or some of the alcoholic or non-alcoholic beverages. The quantity of water required daily by an adult person is usually stated as 3 liters, of which 1 liter is contained in the food ingested, and the other 2 liters must be supplied in the form of plain water or one or other of the beverages named.

A deficient supply of water, or fluid of any kind, tends to induce affections of the kidneys and bladder from the concentrated condition of the blood and excreta. It also manifests itself in diminished nervous activity.

The supply of fluid taken should be so regulated as not to interfere with digestion. Large quantities of fluid taken with, or shortly after the meals, will dilute the gastric juice to such an extent as to retard digestion, and thus lead to disturbances of the digestive function. The experiments of Hawk and his associates have shown that, contrary to the generally accepted opinion, copious water-drinking is not injurious. In fact, in many instances it was found beneficial because of the increased elimination induced.

DIFFERENT VARIETIES OF FOOD.

Animal Foods; Meat.—The flesh of herbivorous animals is most commonly used for food, though that of the pig, an omnivorous animal, is also used extensively in some countries. The flesh of young animals is more tender, because there is less connective tissue between the different muscular bands. Atwater has found that meat and fish are digested to the same extent by healthy men. The meat derived from young animals is less easily digested than that of older animals. Cooked meat is more difficult of digestion than raw meat. The meat of females is also more tender and less coarse than that of males. The flesh of wild animals is less fatty, higher in color, and richer in flavor and extractives than that of domestic animals.

The nitrogenous substances of meat are albumin, creatin, creatinin, sarkin, xanthin, inosin, uric acid, and urea. The muscular sheaths and connective tissue contain also myosin. The proportion of albumin ranges from 0.6 to 4.56 per cent.; Liebig gave the average amount as 2.96 per cent. Prof. Mallet has found, as the result of numerous experiments, that the creatinin is excreted unchanged, while the creatin is changed

wholly or very largely to creatinin, and consequently he believes these two substances cannot be regarded as sources of energy, being excreted practically without having undergone change. The influence of creatin in the system, according to König, is to stimulate the nervous system.

The average composition of albumin may be taken as follows: In 100 parts, nitrogen 16, carbon 54, oxygen 22, hydrogen 7, and sulphur 1. In the group of substances headed by gelatin the proportion of nitrogen (= 18 per cent.) to carbon is greater, and these substances are much less nutritious than the albuminates proper.

Diseases Produced by Diseased Meat.— All animals slaughtered for food should be free from disease. Certain diseases from which the domestic animals suffer are directly communicable to man; others are not directly communicable to man, but the flesh of the animals suffering from them is unfit for food. The inspection should be made both before and after slaughtering.

The diseases of cattle which render their flesh unfit for food are epidemic pleuropneumonia, foot-and-mouth disease, Texas cattle fever, cattle plague, anthrax, actinomycosis, and tuberculosis. Dropsical conditions, as well as all inflammatory conditions, also render the flesh unfit for food. The diseases of the pig which render the flesh unfit for food are anthrax, muco-enteritis, hog-cholera, tuberculosis, Cysticercus cellulosa, and Trichinella spiralis.

Meat Inspection.—Some of the diseases of the domestic animals can be recognized before death, but most of them must be detected by post-mortem examination, either by general inspection of the carcass and of the organs and different portions of the body, or by microscopic examination.

The general inspection includes the observation of the nature and the quantity of fat, the color, odor, and consistence of the muscles, condition of the bone-marrow,

and the condition of the lungs, liver, spleen, kidneys, and the lymphatic glands.

There should not be an excessive amount of fat, or else the proportion of proteid matter will be too low; it should be firm and not too yellow, and without hemorrhagic foci. The color of the fat will vary somewhat with the age, breed, and color of the animal, and the kind of food.

The muscles should be firm yet elastic. They should be tolerably dry and have a pleasant odor. There should be no lividity on cutting across some of the muscles. A purple color may be indicative that the animal has not been slaughtered, or that it suffered from some acute disease. There should be a marbled appearance from the ramification of connective tissue and fat between the muscular bundles.

The bone-marrow of the hind legs is of a light rosy-red color, and remains solid for about twenty-four hours after death. If it is soft, brownish, or with dark points, the animal may have been sick, or putrefaction may be commencing. The marrow of the fore legs is somewhat softer and of a rose-red color.

The internal organs should be carefully inspected for the presence of tumors, parasites, or suppuration. The lungs and pleuræ will usually show the presence of tuberculosis, through the deposition of tubercles. Sometimes these are found first in the lymphatic glands of the mesentery and mediastinum.

The microscopic examination of meat is directed principally toward the detection of parasites, such as the cysticercus, psorospermia, and trichina. The cysticercus may be found in the flesh of cattle and pigs; the psorospermia in the flesh of fish, rabbits, and pigs; and the trichinia in the flesh of pigs. A power of from 25 to 50 diameters is sufficient to detect these parasites in meat.

Method of Meat Inspection.—The method of meat inspection, and the restrictions placed upon the sale of the meat of diseased cattle, differ very greatly in different

countries. For instance, Saxony and Bavaria, in Germany, Italy, Russia, and Denmark allow the sale of the meat of tubercular animals when the disease has not become generalized, providing it is sold with the understanding that it is derived from diseased animals, or is sold as second-class meat. In most foreign countries, as well as in the United States, the meat of tubercular animals is sold without any declaration as to its nature as wholesome meat when the disease is localized.

In the United States the inspection of meat is in charge of the national government. Meat inspectors are stationed at the slaughter-houses of all large cities, and each carcass is inspected as soon as slaughtered. This system of inspection should be extended so as to include towns of smaller size, because, especially in the West, three, four, or more small slaughter-houses are clustered on the outskirts of small towns, and each may become a focus for the dissemination of disease.

Meat intended for export is always subjected to rigid inspection. Edelmann[1] states that pigs' livers imported into Dresden from America or Denmark frequently contain trichinella. But in the year 1896 only four livers out of 2023 were found to be infected, and in each case the parasites were dead, probably owing to the use of antiseptics to preserve the meat. All pork intended for exportation is examined microscopically for the presence of the Trichinella spiralis. This inspection is made by the Federal authorities at the slaughter-house. Most of this work is done in Chicago. In most cities of the United States the meat intended for local consumption is inspected very superficially or not at all.

Ostertag[2] mentions the following points as forming the foundation upon which the rules governing the question of meat inspection must be based:

1. The erection of public slaughter-houses in all cities of more than 5000 inhabitants.

[1] *Zeit. Fleisch- u. Milch-Hyg.*, 1898, p. 64.
[2] *Trans. German Veterinary Council for* 1891.

2. Compelling the butchers to kill their animals in these slaughter-houses, and to discontinue the use of private slaughter-houses.

3. Professional direction of the slaughter-houses, and the inspection of all animals both before and after the slaughter.

4. The provision of stalls for the sale of inferior but not unhealthy meat (not apt to cause disease in man), such as meat of an abnormal color, odor, bloody meat, and that from sick animals. The provision of a cooking or sterilizing apparatus, for cooking such meat as might cause disease if consumed raw, but would be harmless when cooked (meat containing cysticerci, trichina, and tubercle bacilli).

5. The total destruction of those animals and parts of animals which are condemned as unfit for food.

6. The formation of a co-operative insurance society for the purpose of recompensing the owners of condemned cattle. It is best that this society should be conducted by the city or town, in order that the losses might be regularly distributed.

It seems evident, from the experiments of Woodhead and others, that there is positive danger from the use of meat of tubercular animals even though the disease has not been generalized. The point which seems to be entirely overlooked, and to which a great deal of importance should be attached, is that when the disease is localized in one or more organs there is great danger of infecting the entire carcass by the butcher's knife in removing these infected organs. Not only may the carcass containing the tubercular nodules become infected in this manner, but the infection may also be carried on the butcher's knife to the carcasses of other animals slaughtered by him.

Food-poisoning.—Several types of food-poisoning have been recognized. The **first** group of these food-poisonings to be considered is that due to Clostridium botulinus, an anaërobic organism discovered by Van Ermengem in 1895. This organism produces a highly toxic poison in

food which, when taken into the system, has an especial affinity for the nervous system, and hence the character of the symptoms seen in poisoning from tainted food. Kemperer has found that it is possible to counteract these symptoms, at least in part, by means of an antitoxin derived from the blood of animals immunized against the organism. Experiments have shown that dogs are immune to this organism even when fed in their food in pure cultures.

Recently several groups of cases of botulism occurred in different parts of the United States in which "ripe" olives were found to be the food causing the trouble. These cases occurred in Detroit, Mich., Toledo, Ohio, New York City, and in Memphis, Tenn., and were all traced to ripe olives canned in California. The odor and taste of the olives was abnormal, and therefore no food should be eaten when the senses detect any abnormality.

The **second** group results from the development of putrefactive bacteria in originally wholesome foods, and the organisms encountered most frequently belong to the proteus group. The effects produced are due to putrefactive substances—ptomaines—formed as the result of the metabolic action of the bacteria.

The **third** group is caused by bacteria belonging to the hog cholera group. Clinically, the cases are usually characterized by acute, stormy onset, mostly with chills and high fever, severe and sometimes uncontrollable vomiting, violent diarrhea, cramps in the legs, and rapid loss of strength. Occasionally the course is milder and more like that of typhoid fever. Paratyphoid bacilli have been isolated from the organs and tissues of diseased animals, and it is clearly established that under certain circumstances animals from which we obtain food are subject to infection with paratyphoid bacilli. These infections appear to occur only sporadically, and the special conditions necessary for their development are not yet clearly understood.

In the majority of cases of poisoning due to para-

typhoid bacilli it concerns an actual infection with bacilli in addition to intoxication with substances derived from them. This intoxication probably manifests itself in the severe symptoms often characteristic of the beginning of the attack. Paratyphoid bacilli, as well as the Gärtner bacillus, form toxic substances that are able to resist high temperatures and which in smaller animals cause diarrhea and convulsions. When only a small number of bacilli is introduced, it is thought that the milder form of the disease, a form of so-called paratyphoid fever, may develop, and in some of the epidemics both the clinical forms have been observed. Lentz, who has studied 200 cases of paratyphoid infection, saw in about 40 per cent. the typhoid-like course, while in the others the attack began suddenly with high fever and chills. It is interesting to note that in cases of paratyphoid intoxication herpes of the lips and nose is relatively common, and there may be roseola in large spots; there are rarely ulcers in the intestines; occasionally there is a pronounced, often hemorrhagic, enteritis.

Preservation of Meat.—Meat can be preserved in its normal state in cold climates for a week or more without undergoing any change detrimental to health. In warm climates it cannot be preserved longer than a day or two without resorting to some method to prevent the action of the bacteria of putrefaction. The methods in common use for this purpose are desiccation, sterilization by heat, refrigeration, salting, and the use of antiseptic substances,—that is, substances which prevent the development and action of putrefactive bacteria.

Desiccation takes away the moisture and thus prevents the growth of bacteria. In some exceptionally dry climates desiccation takes place on simple exposure to the air. Ordinarily, however, the desiccation must be brought about by artificial heat. In common practice the process is conducted in a smoke-house, where the smoke assists in preserving the meat.

Sterilization by heat is commonly resorted to in the household where other methods of preserving are not

available. This method is also employed commercially, and the sterilized meat is preserved in hermetically sealed receptacles, in which it keeps indefinitely. The so-called "canned meat" used for the United States Army during the Spanish-American War is a form of preserved meat. When the receptacle is once opened, the meat soon undergoes decomposition.

Salting is one of the oldest methods of preserving meat. The action of the salt is to remove moisture, to harden the muscle-fiber, and it is also deterrent to bacterial action, as the putrefactive organisms are unable to develop in the presence of large quantities of salt.

The use of various *antiseptic substances* for the preservation of meat is of recent date. Since all antiseptic substances are poisonous, they should not be employed for this purpose. Meat that has been preserved by means of antiseptic substances is not only poisonous because of the antiseptics contained in it, but it is also objectionable because these antiseptics render it tough and indigestible, and therefore irritant to the gastro-intestinal tract. The antiseptic substances employed for this purpose are boric, benzoic, and salicylic acids, sodium sulphite, and formaldehyd. All these substances hinder the process of digestion, and are therefore harmful.

The only safe and rational method of preserving meat is by *refrigeration*. In this way meat can be stored for a considerable time or shipped long distances without suffering in character or digestibility.

Smoked, salted, and sterilized meats are far more difficult to digest, besides being less palatable and less nutritious than fresh meat. Meat preserved by sterilization is less nutritious and less palatable than fresh meat, and it is also less nutritious because it is overcooked.

Detection of Meat Preservatives.—The Jörgensen[1] method of estimating boric acid in meat preservatives is based upon the fact that a watery solution of boric acid, neutral to phenolphthalein, after being treated with a sufficient quantity of glycerin, again takes on an acid

[1] Abst. in *Hyg. Rundschau*, Bd. x, S. 744.

reaction, and that by subsequent titration with caustic alkali solution the amount of boric acid can be estimated if the value of the alkali solution has been carefully determined.

The sample of meat treated with known amounts of boric acid is made strongly alkaline with caustic soda solution, and then extracted for several hours with hot water. The filtrate is evaporated to dryness, incinerated, and the ash dissolved in sulphuric acid. This solution is gently warmed for some time to remove the carbon dioxid, and, after cooling, is accurately neutralized to phenolphthalein.

The fluid, about 50 c.c. in amount, is then treated with 25 c.c. of glycerin and titrated with $\frac{n}{10}$ NaHO solution without regard to the phosphates that may be precipitated; the end-reaction is made more definite by the addition of ethyl alcohol. In this manner 94.94 per cent. of the boric acid added was recovered.

Borntrăger[1] makes the following statements with regard to the use of sodium sulphite (Na_2SO_3) as a meat preservative: "The extensive use of food preservatives is not generally recognized by the physician. The continued use of food substances preserved in this manner is detrimental to health.

"When sodium sulphite is present in food sulphurous acid gas is liberated in the stomach through the action of the hydrochloric acid of the digestive fluid, and this leads to strong local irritation. The salt also acts in the organism as a free acid.

"After eating Frankfurt, Vienna, or Bock sausage, or drinking the so-called Rhine or Moselle wines, there was eructation of sulphurous acid and hydrogen sulphid, with pressure and discomfort in the stomach, and headache, which lasted a considerable time."

The use of borax, sodium sulphite, and other preservatives in meat produces definite trains of symptoms and

[1] Abst. *Hyg. Rundschau*, Bd. x., S. 743.

pathological conditions, especially lesions of the kidneys, as the result of the attempts at elimination of these poisons.

Although the use of meat preservatives is prohibited by the pure food laws of the United States, there is reason to believe that systematic chemical examinations of meats would reveal frequent employment of these substances. Unless we can invoke the aid of national, state, and municipal governments in inhibiting the use of preservatives of this character, it is probable that the influence of all other hygienic measures which tend to prolong life will be nullified because of the greater detriment exerted by the constant use of meats containing these preservatives.

Cooking.—The value of meat as served on the table is influenced to a considerable extent by the manner in which it is cooked. The object of cooking meat is to render it more easy of mastication and digestion, and to render it more palatable. It also serves to kill any parasites present, and thus prevents infection.

Of the different methods of cooking meat, broiling and roasting are the best, as in these methods the juices of the meat are retained as much as possible. In boiling and stewing a considerable portion of the juices is extracted. Frying in oil renders the meat richer in fats, and therefore more difficult to digest than when roasted or broiled.

Effect of Light and Dark Meats.—In recent years there has been considerable discussion as to the influence of dark meats, especially in cases of chronic parenchymatous nephritis, and in diseases of the nervous system. This differentiation between light and dark meats has been traced back to the time of Sydenham, who allowed his neurasthenic patients the light meat of calves, chickens, and fish, but prohibited the use of beef, because it favored the production of nervous disease. Later it was prohibited because it was believed to favor the production of uric acid. In consequence of this fact the differentiation between light and dark meats began to play an important *rôle* in the treatment of diseases of the kidneys. In recent times stomach and intestinal

diseases, acute and chronic rheumatism, and the functional neuroses are also believed to be influenced unfavorably by the use of the dark meats.

In the treatment of kidney diseases the prohibition of dark meats is based upon the fact that these meats contain a greater proportion of nitrogenous extractives, and that these extractives produce irritation of the kidneys when eliminated, or in deficient action of the kidneys they accumulate in the system and produce toxic effects. The nitrogenous extractives of meat to which this effect is traced are, more especially, the creatin and creatinin, xanthin, leucin and tyrosin, and ptomains, besides other extractives. Smoked and pickled meats contain other irritating products, besides those contained in fresh meat, and are therefore far more injurious.

The trend of opinion at the present time is to minimize the differentiation. Pabst was unable to determine any appreciable difference in the amount of urine excreted, and the proportion of albumin eliminated, with a milk diet, a diet of dark meat, white meat, or a mixed diet.

The explanation for the supposed injurious effects of dark meats has also been attributed to the effect of the simultaneous use of carbohydrates (Kirk). The use of dark meats with the exclusion of the carbohydrates is stated to be of decided advantage in the treatment of neurasthenics. While there is some clinical evidence as to the validity of this assumption, it will be best to await more extended experience before abandoning the teaching of Sydenham.

Composition of Meat.—**Lean beef** is composed of about 76 per cent. of water, 21.5 per cent. of nitrogenous substances, 1.5 per cent. of fat, and 1 per cent. of salts. The composition varies, however, in the same animal according to the part from which it is taken, for instance: The neck contains 73.5 per cent. of water, 19.5 per cent. of nitrogenous substances, 5.8 per cent. of fat, and 1.2 per cent. of salts; the flank, 63.4 per cent. of water, 18.8 per cent. of nitrogenous substances, 16.7 per cent. of fat, and 1.1 per cent. of

salts; the shoulder, 50.5 per cent. of water, 14.5 per cent. of nitrogenous substances, 34 per cent. of fat, and 1 per cent. of salts. With increase in fat the percentage of water decreases; the percentage of nitrogenous substance is, however, increased very little by the fattening process. The percentage of water is also greater in the flesh of young animals than in that of adult animals.

Veal.—Veal is usually more difficult of digestion than beef. Kōnig attributes this to the fact that it is more tender and therefore less resistant to the masticating process, and is, consequently, masticated with more difficulty than other meat. It contains a greater proportion of water than beef. Its nutritive value is dependent upon the age of the calf when slaughtered, the younger it is the more watery the flesh, and the lower the proportion of nutritive substances. In some countries, as in the United States and Austria, veal is not permitted to be used for food under one month of age.

Composition of the Flesh of Domestic Animals.[1]

Animal.	Condition.	Per cent.				
		Water.	Nitrogenous substance.	Fat.	Nitrogen-free extractives.	Ash.
Ox	Very fat	53.05	16.75	29.28	......	0.92
	Medium	72.03	20.96	5.41	0.46	1.14
	Lean	73.67	20.71	1.74	......	1.18
Cow	Fat	70.96	19.86	7.70	0.41	1.07
	Lean	76.35	20.54	1.78	......	1.32
Calf	Fat	72.31	18.88	7.41	0.07	1.33
	Lean	78.82	19.86	0.82	......	0.50
Sheep	Fat	53.31	16.62	28.61	......	0.93
	Lean	75.99	17.11	5.77	......	1.33
Pig	Fat	47.40	14.54	37.34	......	0.72
	Lean	72.57	20.25	6.81	......	1.10
Horse	(Mean)	74.20	21.70	0.46	0.46	1.01

Mutton.—The flesh of sheep and lambs is composed of finer muscular bundles than beef, and is, in general, easily digested.

[1] Mitchell, *Flesh Foods*, London, 1900, p. 47.

Relative Composition of Different Kinds of Meat **(König).**

	Water.	Nitrogenous substances.	Fat.	Nitrogen-free extractive substances.	Salts.	In dry substance. Nitrogenous substances.	In dry substance. Fat.	In dry substance. Nitrogen.
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Ox, fat	45.5	14.5	30.17	...	3.9	...	...	...
Calf, fat (9 analyses)	72.31	18.8	7.41	0.07	1.33	68.87	26.04	11.02
Lamb, fat (9 analyses)	53.31	16.82	28.61	...	0.93	35.59	61.28	5.70
Pork, fat (5 analyses)	47.40	14.54	37.34	...	0.72	28.16	70.44	4.50
Horse (12 analyses)	74.27	21.71	2.55	0.46	1.01	85.69	8.46	13.71
Chicken, fat	76.22	18.48	9.34	1.20	0.91	61.76	31.19	9.88
Duck, wild	70.82	22.65	3.11	2.33	1.09	77.59	10.62	12.92
Goose, fat	38.02	15.91	45.59	...	0.48	38.02	73.55	4.11
Herring (2 analyses)	74.64	14.55	9.03	...	1.78	56.42	35.85	9.03
Trout (8 analyses)	79.63	18.42	0.53	0.46	0.96	90.59	2.42	14.50

Pork.—The nature of the food-supply influences the character of the flesh of pigs to an important extent, especially with regard to its flavor and the deposition of the fat. Pork is more difficult of digestion than the meat of any of the other domestic animals.

Poultry and Game.—The flesh of birds differs from that of mammals in the fact that the fat is deposited in the muscular tissue to only a limited extent. It is also of a more delicate flavor than that of mammals. It is easier to digest than the flesh of mammals and is therefore frequently recommended for invalids.

Fish.—The flesh of most fish is white because their blood is white, though some have red blood. It is rich in water, and varies in its fat content, both quantitatively and qualitatively. The flavor of the flesh is dependent upon the different character of the fat in different fish. The structure of the flesh is similar to that of mammals, and is equally nutritious. According to the investigations of Atwater, the flesh of fish is as readily digestible as beef. There are, however, individual differences.

Milk and Milk-products.—**Cows' Milk.**—Cows' milk forms a most important article of diet in the United States. It is of the greatest importance, therefore, that the milk placed on the market should be as pure and wholesome as possible. The fact that milk is such a

favorable culture-medium for most classes of bacteria makes it possible for it to become the carrier of disease-producing organisms. It may also be dangerous because of the presence of disease-producing bacteria derived from the cow, or because of the presence and growth of non-pathogenic forms. If the milk could be collected and stored in such a manner as to prevent the entrance of bacteria, it would keep a long time; but this is impossible, because it is frequently contaminated with bacteria in the milk-ducts of the udder. It is also further contaminated with bacteria derived from the fur and udder of the cow, the hands of the milker, the air of the stable and milk-house, and the utensils in which it is collected and stored.

Some of these bacteria, as the lactic-acid group, ferment the lactose and produce lactic acid, causing the milk to turn sour and the casein often to coagulate. Other classes of bacteria cause the milk to decompose, with the production of odors; these are the putrefactive organisms. It has been found that storing the milk in an ice-chest for several days inhibits the multiplication of the lactic-acid group of bacteria, but does not inhibit the multiplication of the putrefactive bacteria, so that the milk under these conditions becomes putrid before it turns sour.

Pure and wholesome milk can be obtained only from healthy cows, but the milk of healthy cows may soon be rendered useless through carelessness in collecting and storing. The precautions necessary for the marketing of pure and wholesome milk are, therefore, far-reaching, numerous, and exacting. These precautionary measures should include the selection of healthy cows; the treatment and housing should be such as to favor the maintenance of their health; the utmost cleanliness about the stables and milk-house; the cleanliness of the milker and of those who handle and market the milk; the utmost cleanliness of all utensils employed in collecting, storing, and marketing milk.

Diseases Conveyed through Milk.—A number of diseases may be conveyed through milk, and they may be derived either from the cow yielding the milk or from those who come in contact with the milk in collecting and marketing it. The diseases that may be conveyed directly from the cow are tuberculosis and micro-organisms of inflammatory diseases, such as the Streptococcus and Staphylococcus pyogenes.

While the positive conveyance of tuberculosis from the domestic animals to man is still disputed by some, especially that of bovine tuberculosis through the use of the milk and meat of tubercular animals, because of slight morphologic and biologic differences between the bacillus as found in bovine and human tuberculosis, the trend of opinion to-day is in favor of regarding the milk of all tubercular animals as dangerous to health. The direct transmission of bovine tuberculosis to members of the human family is infrequently demonstrated, because of the insidious onset of the disease and its slow progress; yet there are some cases on record which appear beyond a doubt to have been contracted in this manner. Leonhart reports the case of a healthy infant, of healthy parents, which was weaned and put on cows' milk. The child soon died of tuberculosis of the meninges, intestines, and mesenteric glands. The cow from which the milk was derived was found to be tuberculous. Another child fed on the milk of the same cow died, at about the same time, from tubercular meningitis. Sonntag reports the case of a six months' old infant, of healthy parents, which at autopsy showed miliary tuberculosis of the meninges. It was fed on milk derived from a tubercular cow. Hermsdorf gives 3 instances in which there was extensive intestinal tuberculosis, besides general affection of other organs. One had taken uncooked milk from a tubercular cow. Demme reports the case of a four months' old infant which at autopsy showed tuberculosis of the mesenteric glands. There was no tuberculosis in the family for two generations on either side. The milk

came from a cow with general tuberculosis. Bollinger cites Stang's case of a boy of five years, who sickened with ascites and enlarged glands in the abdomen. At autopsy the chief lesion was tuberculosis of the abdominal lymphatics, but there was also tuberculosis of the serous membranes and of the lungs. There was no tuberculosis in the family for two generations. The child had for years been in the habit of drinking milk warm from a cow, which, growing thin before the boy died, was killed, and found to be tubercular.

Holt reports on 1045 consecutive autopsies from the records of the New York Infant Asylum and Babies' Hospital—10 per cent. of which were found to be tuberculous. In the latter institution, which receives only sick children, the percentage was higher.

To guard against the dangers of infection through the use of milk from tubercular cows the thorough inspection of all cows kept for breeding purposes, or whose milk is offered for general consumption, should be insisted upon. The most reliable and ready method known to-day, by means of which we can detect the disease, even in its incipient stage, is the tuberculin test. This test is now employed in many States and in many foreign countries, and, if the tuberculin has been prepared by competent bacteriologists, it is believed to be without detrimental effects on healthy animals.

Dr. John R. Mohler, Chief of the Pathological Division, Bureau of Animal Industry, investigated the "Infectiveness of Milk of Cows which have reacted to the Tuberculin Test," and reached the following conclusions:

The tubercle bacillus may be demonstrated in milk from tuberculous cows when the udders show no perceptible evidence of disease either macroscopically or microscopically.

The bacillus of tuberculosis may be excreted from such an udder in sufficient numbers to produce infection in experimental animals both by ingestion and inoculation.

That in cows suffering from tuberculosis the udders may become infected at any moment.

The presence of tubercle bacillus in the milk of tuberculous cows is not constant, but varies from day to day.

Cows secreting virulent milk may be affected with tuberculosis to a degree that can be detected only by the tuberculin test. Physical examination or the general appearance of the animal does not always reveal the disease.

The milk of all cows which have reacted to the tuberculin test should be considered as suspicious, and should be subjected to sterilization before using.

Still better, tuberculous cows should not be used for general dairy purposes.

Beck, of Berlin, reported on an investigation of 56 samples of market milk as to the presence of pathogenic bacteria in such milk. He found tubercle bacilli in 30.3 per cent. of the samples, and streptococci in 62.3 per cent. These streptococci were pathogenic for guinea-pigs when injected intraperitoneally, the animals dying in from three to four days from a purulent peritonitis. The peritoneal exudate usually contained the streptococci in pure cultures. Mice were killed in about twenty-four hours by subcutaneous and intraperitoneal injections of small amounts of a bouillon culture of the streptococci, with symptoms of general infection. Rabbits died in two or three days after intravenous injections of a few drops of a bouillon culture; in some instances serous, purulent exudates into the joints were observed. A fresh culture rubbed into the skin of the rabbit's ear was productive of an erysipelatous inflammation of the entire ear, with considerable fever, though all of these animals recovered. The injection of 1 to 3.5 cubic centimeters of a fresh bouillon culture into the stomach of guinea-pigs resulted in the production of severe diarrhea, some of the animals dying of enteritis. On post-mortem examination of these animals the mucous membrane of the intestine was found to be markedly red-

dened, showing ecchymoses, and the fluid contents of the intestine contained numerous streptococci.

Beck believes these streptococci to be closely related to those found by Escherich in the enteritis of infants. He states that Romme also believes in the danger of infantile enteritis from these streptococci.

The use of milk derived from cows suffering from inflammatory disease of the milk-ducts is undoubtedly productive of inflammatory conditions of the gastro-intestinal tract, especially in infants. The cases of fatal streptococcus enteritis reported by Hirsch and Libbert appear to have been cases of this kind. Booker is also of the opinion that gastro-enteritis is not infrequently produced in this manner.

Of the diseases conveyed in milk, aside from those derived from the cows themselves, may be mentioned typhoid fever, cholera, diphtheria, and scarlet fever. These diseases are not produced by infection derived from the cows, but by contamination of the milk with polluted water, or by means of flies, and by means of infected hands and clothing of the milkers or those employed in collecting and marketing the milk.

Typhoid fever and cholera may be conveyed through milk in very much the same manner. These diseases are most frequently conveyed through impure drinking-water, but when the milking utensils are washed in polluted water, or the milk is diluted with water containing the typhoid and cholera organisms, the diseases may be conveyed in this manner. Again, flies and other insects are no doubt frequently concerned in conveying these diseases by coming in contact with the fresh evacuations of patients suffering therefrom, and then subsequently infecting milk. For these reasons the storing of milk in such a manner as to prevent the possibility of this mode of infection is of the greatest importance.

Diphtheria and scarlet fever may be conveyed in milk; and a number of epidemics of these diseases have been traced to their source in contaminated milk. The most common mode of contamination is through the infected

hands of milkers and those handling the milk. The most rigid care should be exercised to avoid the dissemination of these diseases in this manner. No one suffering from these diseases, nor any one coming in contact with those suffering from them, should be allowed to milk or handle any milk that is intended for general consumption. There is no evidence at hand to substantiate the belief that cattle suffer from either of these diseases. The milk is usually contaminated by the family of the dairyman, or others through whose hands the milk passes on its way to the consumer.

Municipal Control of the Milk-supply.—In order to make it possible for the poorer classes to obtain a milk-supply that is free from danger, it is necessary for municipalities to institute certain regulations to control the marketing of milk. This is especially necessary on account of the relation of the milk-supply to the high infantile mortality. There should be direct supervision of the dairies and their surroundings. This should include an investigation and repeated inspection of the health of the herd, the nature of their food-supply, the purity of the water on the farm, and the general sanitary conditions on the farm. All the milk-dealers in the city should be licensed, and their wagons distinctly marked so as to indicate the name of the dealer and the source of the milk. Especial importance should be attached to the sale of milk in stores and the sanitary precautions required in storing milk. The use of all preservatives must be strictly prohibited on account of their detrimental influence on health.

New Milk Law of Philadelphia.—The efforts to improve the milk supply of Philadelphia have led to the appointment of a commission which, in its report, makes numerous recommendations concerning the collection and distribution of milk. The commission recommended that the milk should reach the city at a temperature not exceeding 50° F. This regulation, if enforced, will prevent the enormous multiplication of bacteria in milk in transportation to the city.

Production of Wholesome Milk.—The production of clean, wholesome milk requires attention to the health and cleanliness of the persons milking the cows and handling the milk; to health, stabling, feeding, and general care of the cows; to the cleanliness and care of the utensils in which the milk is collected, stored, and marketed; and to care with which the milk is handled in the household.

No person who is suffering from any of the infectious diseases, or who comes in contact with such persons, should be allowed to handle the milk or milking utensils. Persons suffering from acute or chronic catarrhal affections of the respiratory system, from tuberculosis, or who have recently recovered from typhoid fever, dysentery, cholera, scarlet fever, measles, diphtheria, or small-pox should be allowed about the dairy. Persons attending patients suffering from any of the acute infectious diseases should also be excluded from the dairy.

Rigid cleanliness of body and clothing of all attendants about the stables and dairies, or engaged in handling the milk, is essential to the production of wholesome milk.

A number of epidemics of typhoid fever have been traced to persons who were typhoid bacillus carriers that were engaged about dairies, on milk wagons, or in shops where milk is disposed from large containers.

The stables in which dairy cattle are kept should be but one story in height and well ventilated. The floors should be of impervious material, preferably cement, so as to prevent the accumulation of filth to undergo decomposition. The bedding should consist of absorbent material, which gives rise to the least amount of dust; the manure should be removed twice a day and stored at some distance from the stable. The walls of the stable should be whitewashed once or twice a year. The cows must be healthy stock. Special care should be taken to exclude all tuberculous animals. The herd should be tested twice a year by a skilled veterinarian. All animals reacting to the tuberculin test should be removed from the dairy. Cows suffering from infection of the udder,

or other infectious disease, should also be removed until such time as they may have recovered from the infection. No cows should be added to the dairy until it has been demonstrated that they are in a sound and healthy condition.

The entire body of the cow should be cleaned each day, and just before milking the udder and flanks should be brushed and wiped with a clean damp cloth.

The milker should be clothed with clean clothes, wash his hands before milking each cow, and milk with dry hands. Wet-milking should be rigidly prohibited.

All the utensils used in collecting, cooling, and storing the milk should be cleaned and sterilized before they are used. The milk should be bottled as quickly as possible, and the bottles packed in ice or placed in cold storage until shipment is made.

When the milk reaches the consumer it should be placed in a clean refrigerator to keep it cold, and it should be removed from the bottle at the time it is to be used. Milk that has been removed from the bottle should not be returned when it is not used at once.

Pasteurization of Milk.—Most of the milk shipped to the larger cities is sent in bulk from long distances and reaches the consumer with large numbers of bacteria. Frequently milk is encountered containing millions of bacteria of various sorts. Because this milk does not keep many hours in hot weather, and especially because it frequently contains infectious bacteria, it has been generally advocated that the safest procedure is to subject it to heat—that is, pasteurize it.

A number of varieties of pasteurizing machines are on the market; but the processes by which pasteurization is accomplished may be divided into two principal types—the flash process and the holding process. In the flash process the milk passes through the apparatus, and in one part of its course it is heated momentarily to the boiling-point and is quickly cooled by passing through a compartment cooled by ice or brine. In the holding process the milk is quickly heated up to 60° to 65° C., and

held at that temperature for twenty to thirty minutes. The latter process is far more certain of killing all disease-producing bacteria.

Pasteurized milk, where the process is conducted in a proper manner, is a safe milk. If the pasteurization is carried out in the bottles in which the milk is delivered to the consumer, there is no danger of conveying any of the infectious diseases through the milk-supply. Pasteurized milk is just as wholesome as raw milk, though it does not keep as long as a clean raw milk, because not all the bacteria are killed during the process of pasteurization. Any bacterial spores that are in the milk may, and usually do, survive the pasteurization, and unless the milk is kept at a low temperature the spores germinate and multiply rapidly, producing objectionable and even harmful metabolic products.

Certified Milk.—Certified milk is produced in many parts of the country. It consists of milk of dairies that are conducted on the most approved methods. All the cows are tested by a veterinarian in the employ of the local milk commission. The arrangements of the stables and milk house are such as to make it possible to collect the milk in such a manner as to exclude most of the extraneous bacteria, and the milk is bottled as quickly as possible and served to the consumer in these containers. The chemical and bacteriologic composition of the milk is tested by experts in the employ of the milk commission. The inspection and analytical work is paid by the producers, and the milk is sold at a higher price than ordinary milk.

Certified milk is used for infant feeding and for sick and convalescing patients. The bacterial content of certified milk is generally less than 10,000, and frequently only several hundred bacteria are found in each cubic centimeter, and these are largely the ordinary lactic-acid bacteria which are found in all normal milk.

Butter.—Butter serves as an important source of fat in the food of most people. It is very palatable to most persons, and it is easily digested when fresh and pure.

When kept for some time butter becomes rancid—that is, the fat becomes changed through the action of bacteria contained in the butter, and in this condition it is more difficult to digest.

Butter may be injurious to health in two ways: It may contain the specific micro-organisms of certain diseases, as the typhoid bacillus or the Bacillus tuberculosis, or the presence of other fats of animal or vegetable origin. The typhoid bacillus may be present in butter through the use of polluted water in washing the utensils used in the collection and storing of the milk, or in making the butter. The Bacillus tuberculosis may be derived from the cows from which the milk is obtained. Virulent tubercle bacilli have been found a number of times in butter made from the milk of tubercular cows.

The addition of other fatty substances to butter, or the substitution of these fats for butter, under the names of butterine and oleomargarin, is now prohibited by law, though it is by no means infrequent even at the present time. These fats are usually more difficult of digestion, aside from the fact that they are fraudulent substitutes for a more costly article of diet. If fats derived from diseased animals are added to butter, the bacteria contained in these may be a source of danger to the consumer.

Cheese.—The high nutritive value of cheese and its cheapness make it an important article of food, especially for the poorer classes.

Cheese may be injurious to health on account of the presence of tubercle bacilli when the milk is derived from tubercular cows, though it is claimed these organisms cannot live in cheese for more than fourteen days. The typhoid bacillus and cholera organism die after a very few days. Cheese may also be injurious to health because of the presence of poisonous products of non-pathogenic bacteria of certain species. This poisonous substance is of the nature of a ptomain. It has been extensively studied by Vaughan, who has called it tyrotoxicon. This form of poisoning by cheese is not infre-

quent. It may also occur in ice-cream, and in milk under certain circumstances. It is accompanied by grave gastro-intestinal disturbances and marked nervous depression.

Eggs as Food.—Eggs are used as food in very large quantities, and their use as a food has become a question of unusual importance in recent years because of the increasing demands for fresh eggs in feeding tuberculous individuals. Eggs derived from healthy hens are occasionally contaminated with fecal bacteria. Hens suffering from chronic bacillary infection of the oviduct yield eggs that appear normal, but which may contain considerable numbers of bacteria.

Eggs that have been kept in cold storage for a time are in danger of the invasion of bacteria from the exterior. Under these circumstance the eggs may be highly injurious to the health of the consumer. The danger of the invasion of the interior of the egg by bacteria is still greater when the eggs are moist. When the shell is cracked, bacteria enter at once and produce alterations which, in a short time, render the egg putrid.

Vegetable Foods.—The vegetable foods exceed in number and form those derived from the animal kingdom. They differ from the animal foods principally in the form in which the nutritive substances (nitrogenous matter and fat) occur, and in the presence of starch, gums, sugars, and other nitrogen-free extractives which do not occur in animal foods. These latter substances contained in vegetable foods take the place, in part, of the fats in animal foods. The various forms of sugar found in vegetable foods, as glucose, saccharose, mannose, etc., take the place of the lactose and inosit of animal foods. Another nitrogen-free substance present in vegetable foods which is not found in animal foods is cellulose, which is partly digested, and in part serves other useful purposes in foods.

The nitrogenous substances contained in vegetable foods are vegetable albumin and casein, gluten, nuclein, besides other nitrogenous substances, as asparagin, leucin, amygdalin, allantoin, lecithin, etc.

The mineral substances contained in vegetable foods are qualitatively the same as those contained in animal foods.

Composition of the Cereals.

Cereal.	No. of analyses.	Nitrogenous substances.	Fat.	Nitrogen-free extractives.	Cellulose.	Ash.	Nitrogen.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Wheat	1358	13.89	2.20	79.75	2.19	1.97	2.22
Rye, winter .	173	12.48	1.77	81.04	1.78	2.06	2.00
Barley	766	11.24	1.93	77.24	4.95	2.42	1.79
Oats	377	12.13	4.99	66.41	10.58	3.29	1.94
Corn, flint . .	80	11.74	4.78	79.20	1.67	1.40	1.88
Rice	10	7.00	2.00	84.76	4.00	1.16	1.12

Composition of the Leguminosæ.

	No. of analyses.	Nitrogenous substances.	Fat.	Nitrogen-free extractives.	Cellulose.	Ash.	Nitrogen.
		Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.
Beans	63	29.26	1.68	55.86	8.06	3.13	4.68
Peas	72	26.39	1.39	61.21	5.68	2.68	4.30

The high protein content of the legumes makes these a valuable source of nitrogen. They are comparatively low in price, and are therefore at the command of families in the poorest circumstances. Their digestibility and flavor are dependent largely upon the method of preparation. When used in excessive amounts they give rise to flatulency, and hence should always be combined with other articles of food.

The proportion of water in vegetable foods varies greatly, ranging from about 90 per cent. in beets and turnips, to as low as 10 per cent. in some kinds of flour. In general, the dry seeds, as wheat, corn, beans, and different kinds of flour, contain about one-eighth part water and about seven-eighths parts nutrients. Beans and peas contain the largest proportions of proteid matter, and cornmeal, potatoes, rice, turnips, and beets the least. Of the cereals, wheat is the richest in proteid material. Wheat bread differs from wheat flour principally in the greater proportion of water present.

Comparison of Flour and Bread (Atwater).

	Water.	Nutrients.	Proteid matter.	Fat.	Carbohydrates.	Mineral matter.	Fuel value of 1 gram.
	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Per ct.	Calories.
Wheat flour . .	12.00	88.00	12.00	1.00	74.00	1.00	3.616
Baker's bread . .	32.00	68.00	9.00	2.00	56.00	1.00	2.866

Bread.—In bread-making the changes brought about by the process are twofold. The carbon dioxid generated by the yeast, or forced into the dough, causes it to be light and filled with small cavities. If the carbon dioxid is generated by the fermentative action of the yeast plant, the sugar present is converted into carbon dioxid, and at the same time a little lactic and butyric acids are formed, besides some extractive matter. A portion of the starch is also converted into dextrin and sugar. During the process of baking the fermentative action of the yeast plant is arrested and a portion of the albumin is coagulated. In bread made with the aid of baking-powders or by forcing carbon dioxid into the dough the products of fermentation are absent, and the only change produced is that brought about by the heat in baking.

Baking-powders.—There are four classes of baking-powders in use, the one class deriving its carbon dioxid from sodium bicarbonate through the action of tartaric acid. Another class is frequently called "cream-of-tartar" baking-powder because potassium acid tartrate is used to act upon the sodium bicarbonate to generate the carbon dioxid. Another class of baking-powders differs from the foregoing in the use of phosphoric acid; these are called the phosphatic baking-powders. The other class of baking-powders is the "alum" baking-powders, because in these the double sulphate of aluminum and sodium is generally employed to act upon the bicarbonate to generate the carbon dioxid.

The use of baking-powders leaves in the bread or biscuits some of the chemicals of which these powders are composed. All the baking-powders contain sodium bicarbonate from which the carbon dioxid is evolved.

When tartaric acid is used to evolve the carbon dioxid from the sodium bicarbonate, sodium tartrate remains in the dough. When cream of tartar, potassium acid tartrate, is used, rochelle salts, sodium potassium tartrate, remains. When calcium acid phosphate is used, calcium phosphate and disodium phosphate remain. When sodium aluminum sulphate is used, aluminum hydrate and sodium sulphate remain. In each instance the salts remaining in the dough have cathartic effects. In addition to this, the tartrates also have a diuretic action. The manufacturers of the alum baking-powders claim there is no "alum" remaining in the finished products, but have nothing to say concerning the aluminium hydrate that remains.

It will be seen that all baking-powders leave more or less injurious salts in the finished products, and therefore the use of baking-powders should be reduced to the lowest possible limit. Using 100 parts of sodium bicarbonate from which to liberate the carbon dioxid, appropriate amounts of each of the four liberating chemicals will yield equal amounts—52 parts—of carbon dioxid. Under these conditions the quantities of chemicals required to liberate the carbon dioxid and the quantities of the salts remaining in the finished products are as follows:

Chemicals used.	Parts needed.	Salts remaining.	Parts formed.
Tartaric acid	88	Sodium tartrate	115
Potassium acid tartrate	223	Sodium-potassium tartrate	250
Calcium acid phosphate	104	Calcium phosphate	46
		Disodium phosphate	84
Sodium-aluminum sulphate	96	Aluminum hydrate	30
		Sodium sulphate	112

Preserved Meats.—Meats may be preserved against decomposition in several ways, as drying, smoking, salting, canning, and the use of low temperatures.

The use of dried, smoked, and salted meats can be traced back many years, and the hygienic significance of these food-products is well known. Canned meats,

when the canning process is carried out properly on fresh meats, are valuable food-products.

The use of low temperatures (cold storage) for the preservation of meats has come into great prominence in recent years. When meats are stored after they have been invaded by bacteria these food-products may prove dangerous to the consumer. This is also the case with meats that are stored at temperatures that do not inhibit bacterial action. Cold storage of meats should receive the most careful supervision of the government.

Preserved Vegetable Foods.—Vegetable foods may be preserved in several ways. The method which has long been in use is that of *drying*. This method is still used very generally in preserving certain kinds of food. The modification of this method in use in large manufactories consists in exposing the fruit to the fumes of burning sulphur in a special apparatus. The fruit, when contained in galvanized-iron trays, is certain to take up appreciable amounts of zinc oxid. This fact has led to restriction of the importation of American dried fruits into foreign countries. The substitution of wooden, tin, or aluminum trays will obviate the danger of contamination with zinc. The amount of zinc formed averages about 10 milligrams for every 100 grams of the fruit. While this amount of zinc is probably harmless when taken occasionally, yet when constantly present in food may produce derangement of health through its irritant effect.

The dehydration of vegetables and other foods has come into very general use, especially during the World War. A great variety of foods are now marketed in the dehydrated state, and when served properly cannot be differentiated from fresh foods. Foods of this class are a great economic saving, as they can be kept for a long time and retain all their original qualities. These foods are easily digested and free from injurious effects on the health of the users.

Another method of preserving vegetable foods is by means of *heat*. This method is unobjectionable where

the food is stored in containers that yield no poisonous substances. The preservation of vegetable foods in tin cans is quite common, and there is some danger of lead-poisoning from these foods on account of the presence of lead in the solder employed in sealing the cans. This is especially the case with acid foods or foods that have been imperfectly preserved so that the putrefactive organisms are not all destroyed. In such instances there is danger of solution of the lead through the action of bacterial products upon the solder.

Application of low temperatures in the preservation of vegetable food-products has come into great prominence in recent years and has aided in the conservation of food-products to a marked degree. When vegetable foods are stored at proper temperatures no harm can result from the use of such foods.

Vegetable foods may also be preserved by the addition of *antiseptic substances*, so as to prevent the growth of micro-organisms. The antiseptics most commonly employed are benzoic and salicylic acid and formaldehyd. These substances are in themselves irritant poisons when taken in certain amounts, while smaller amounts used for a long time are positively injurious, because of the irritant effect produced on the gastro-intestinal tract, and the inhibiting influence which they produce on the digestive processes. They are also injurious through the action they have on albuminous food-substances, in that they render them difficult of digestion. The use of all preservatives of this class should be strictly prohibited by law.

Food preservatives have been investigated by Prof. Bigelow, of the Agricultural Department at Washington, who finds that their manufacture has become a distinct line of business. Out of 67 samples of the most common preservatives in use, each of which was obtained with great difficulty when it was known that it was wanted for a chemical analysis, 33 contained borax or boric acid; 10 sodium, potassium, or calcium sulphite; 8 salicylic acid or its sodium compound; 7 benzoic acid

or its sodium compound; 1 boric acid and salicylic acid; 1 boric acid and ammonium fluorid; 2 pyroligneous acid; and 1 β-naphtol. Prof. Bigelow holds that those undoubtedly injurious, such as formaldehyd, salicylic acid, and sulphites, should be proscribed, and a stringent law enacted to control the use of the less harmful ones.

Nuts and Their Uses as Food.—Nuts are a very concentrated food, even more so than cheese, but when used at regular meals they are well assimilated and may form a part of a well-balanced diet. Nuts are a very valuable source of protein and fat, these two nutrients being the characteristic constituents of the more common nuts, of which the walnut and cocoanut may be taken as types. In the chestnut carbohydrates are a characteristic constituent. It is undoubtedly better to use nuts as a part of the regular diet than as a condiment or to supplement an otherwise hearty meal. Persons who use nuts in place of meat should not depend upon them as the main food-supply, but should supplement them with more bulky foods with a low content of protein and fat. Nuts may be classed among the staple foods, and not simply as food accessories.

Mineral Food.—The most important mineral food is sodium chlorid. It plays an important *rôle* in favoring the secretion of the digestive fluids. A drop of dilute salt solution placed upon the gastric mucous membrane of an animal causes a pouring out of gastric juice by the glands of the stomach. When taken into the mouth it causes the saliva to flow freely. Vegetable foods are somewhat deficient in salts, and require the addition of sodium chlorid to make up this deficiency, as well as to enhance their flavor and palatability. The vegetable foods are richer in potassium salts, and these, combining with the sodium salts of the body, cause an increased excretion of the latter; this action being compensated by the addition of sodium chlorid to the food. The amount of sodium chlorid taken during a year in a mixed diet ranges from 5 to 7 kilograms.

The other mineral food-substances contained in both

vegetable and animal food are calcium and potassium phosphate; potassium, calcium, and sodium carbonate; and magnesium phosphate. All of these mineral substances have important nutritive functions in the body, but they are present in sufficient quantities in mixed diets, so that no further additions are required.

Beverages and Condiments.—Beverages may be classed as alcoholic and non-alcoholic. The alcoholic beverages differ from each other not only in the quantity of alcohol present, but also with regard to the presence of various extractive substances and the amount and character of the mineral constituents.

Alcoholic Beverages.—Physiologic experiments have demonstrated that the alcoholic beverages may be regarded as articles of food, not only on account of the quantity of alcohol present, but also on account of the extractives which they contain. They serve to stimulate the digestion, the circulation, and the nervous system. They also diminish the oxidation processes of the body and lower the temperature. Small amounts of alcohol may be taken daily in the food, and, according to Prof. Atwater's experiments, these small amounts are oxidized in the system and are therefore a source of energy.

The principal objection to the use of alcoholic beverages is the fact that their constant use tends to the acquirement of the drink-habit. The constant use of large amounts of alcohol leads to grave derangement of health, and for this reason the use of alcoholic beverages is to be condemned, except under special conditions in disease where such a stimulant may be required.

Non-alcoholic Beverages.—The more important non-alcoholic beverages, besides water, are tea, coffee, and cocoa. These beverages have a stimulating effect because of the presence of an alkaloid in each—thein in tea, caffein in coffee, and theobromin in cocoa. Besides these alkaloids they contain various extractive substances and volatile oils, to which they owe their peculiar aroma. These beverages have no nutritive qualities in themselves, but the addition of sugar and milk makes them

nutritious. Their principal effect is one of stimulation. They are used largely as convenient modes of administering water with the food.

The chief hygienic interest of these beverages is in the effects produced by excessive usage. The effects produced are most commonly insomnia, nervous irritability, indigestion, and palpitation of the heart.

Consumption of Fluids.—*The American Grocer* has been collecting statistics concerning the home consumption of beverages, excepting water and soda-fountain products, for the year 1900. According to this authority, the amount spent was $1,228,674,925, in the following proportions:

Alcoholic drinks	$1,059,563,787
Coffee	125,798,530
Tea	37,312,608
Cocoa	6,000,000
Total	$1,228,674,925

The consumption of spirits per capita fell from 5.4 liters in 1891 to 4.8 liters in 1900; wine, from 1.7 to 1.5 liters; and beer increased from 57.9 to 60.6 liters.

Condiments.—Condiments are substances added to food to increase its palatability and to stimulate the appetite. The principal condiments are vinegar and lime- and lemon-juice when acids are desired, and mustard and pepper. These substances play an important part in digestion and nutrition. Their principal hygienic interest is with regard to excessive usage. The excessive use of vinegar tends to produce a watery condition of the blood, and is therefore injurious. The excessive use of mustard and pepper produces overstimulation of the digestive function, and finally leads to irritation and inflammation of the mucous membrane of the gastro-intestinal tract.

Adulterations of Food.—Adulterations of food are of two kinds, injurious and non-injurious to health. Those which are without injurious effect are the most numerous, yet they are of importance because of their fraudulent character. They are chiefly of two kinds, the substitu-

tion of an inferior grade and the substitution of inert foreign substances. They are of hygienic importance because the food so adulterated is of lower nutritive value, and may, therefore, lead to deficient nutrition. In this manner they may pave the way to disease by reducing the natural resistance of the body. A large majority of this class of adulterants is used to increase bulk and weight, cheapen the article, and rob the consumer. Among the poisonous adulterants employed are those used to color and cheapen confectionery, liquors, and canned vegetables, and the various antiseptics employed to preserve food.

Milk is most frequently adulterated by the addition of water, and at times by the abstraction of some of the cream. Milk altered in this way is not directly injurious to health, as a rule, but may be indirectly injurious because of its altered nutritive character. This form of adulteration may also be directly injurious to health when the milk is diluted with polluted water. Milk is also adulterated by the addition of coloring-matter to conceal dilution with water and the abstraction of cream, as well as by the addition of various preservatives. The latter are all directly injurious to health when used for a considerable time.

Butter is usually adulterated by the addition of other animal and vegetable fats, or the entire substitution of these fats for the butter fats. While these fats are somewhat more difficult of digestion, they are perhaps not otherwise injurious to health. The custom of adding chemical preservatives to the milk supplied to creameries, as now practised by small farmers who store the milk for several days before delivering it, yields butter containing these preservatives. Such butter, when used constantly in large quantities, may prove injurious to health.

Tea is adulterated in different ways. It may be treated with different substances to impart a definite color to the leaves; it may be partly exhausted of its active principle and extractives; there may be a substitution of foreign leaves, such as those of the ash, willow, sloe, birch,

hawthorn, raspberry, etc.; the addition of foreign astringents, as catechu; or the addition of different forms of mineral matter, as soapstone, gypsum, iron salts, copper, sand, etc.

Coffee is adulterated by the addition of coloring-matter, the addition and substitution of chicory, acorns, figs, leguminous seeds, and cereals. While these substitutes, or imitation coffees, are without detriment to health, they are distinct frauds, and are indirectly injurious when the stimulating influence of coffee is especially desired.

Cocoa is very commonly adulterated, and sugar and starch are most frequently employed for this purpose. The addition of these adulterants necessitates the addition of some coloring-matter to conceal their presence.

Lard is commonly adulterated by the addition and substitution of cottonseed oil; stearins derived from lard, beef fat, and cottonseed oil; and the fat of animals that have died of disease.

Canned vegetables are adulterated by the addition of salts of copper and zinc to give them a bright-green color. These salts are often present in sufficient quantities to be directly poisonous. Canned vegetables are also frequently adulterated by the addition of antiseptic substances to assist in preserving them. These substances are all more or less poisonous, especially when used for some time. Canned vegetables also frequently contain lead from the vessels containing them. In Germany the law requires that the tins employed to hold the canned good shall not contain more than 1 per cent. of lead. In this country there is no restriction, and as high as 12 per cent. of lead has been found.

Malt liquors are most frequently adulterated by the addition of preservatives, especially salicylic acid. The presence of salicylic acid in beer, for instance, cannot fail, in time, to give rise to disturbances of the health in those who take large quantities of it daily.

Mustard and *pepper* are frequently adulterated by the addition of flour, rice, corn, and ginger.

Vinegar is adulterated by the addition of the mineral acids and water.

Dietaries.—The diet of different individuals is influenced by a great many conditions, such as the financial and social status, the age, sex, and state of health, the temperature and climate of the place, the amount of work performed, and the availability of different articles of food. Diet is also influenced to a great extent by the habits and idiosyncrasies of the individual. Moleschott's standard diet is generally considered to be a fair average diet for an adult man. According to De Chaumont, a certain definite proportion between the carbon and nitrogen ought to be maintained. This proportion should be nitrogen 1 to carbon 15.

Diet in Infancy.—The natural diet of infants for the first fifteen to eighteen months is the mother's milk. If this fails, it is necessary to substitute some artificial food. A good substitute for mother's milk is cows' milk. Since cows' milk is richer in proteid material and poorer in sugar than mother's milk, it is necessary to dilute the milk and at the same time sweeten it. The extent of the dilution of cows' milk required must be determined with regard to the purity and richness of the cows' milk, and, especially, with reference to the digestive powers of the infant. The milk of the goat, ass, and mare are also good substitutes for mother's milk. In some localities these are more easily obtained than cows' milk. All farinaceous foods should be avoided until the incisor teeth have made their appearance.

Diet in Childhood.—After the period of infancy the diet may be gradually varied by the addition of rice or arrowroot to the milk, and by supplying one soft-boiled egg daily. König gives the following as a complete daily diet for children of six to seven years of age: Meat (raw), 170 grams; bread, 300 grams; potatoes, 180 grams; fat (butter and lard), 15 grams; milk, 250 grams; flour, for soup, 100 grams; vegetables (various), 180 grams; or a total of 1195 grams. This yields 78 grams of nitrogen, 43.3 grams of fat, and 281 grams of carbohydrates.

Subsistence Diet for Adults.—Playfair gives the diet sufficient for the internal mechanical work of the body as follows: Proteids, 57 grams; fat, 14 grams; carbohydrates,

340 grams; and salts, 14 grams; but it is doubtful if an average man could subsist on this diet without losing weight, as there is no allowance for any bodily exertion. When allowance is made for slight bodily exertion the amounts are as follows: Proteids, 71 grams; fats, 28 grams; carbohydrates, 340 grams; and salts, 14 grams. For moderate work (93 kilogram-meters), Moleschott gives the following amounts for a man of 68 kilograms: Proteids, 130 grams; fats, 84 grams; carbohydrates, 404 grams; and salts, 30 grams. For a man performing very laborious work, or for a soldier in the field, the amounts should be: Proteids, 170 to 198 grams; fats, 99 to 128; carbohydrates, 454 to 510 grams; and salts, 34 to 43 grams.

A balanced ration is a diet in which the ingesta are just equal to the excreta. As an instance of complete equilibrium in a man weighing 70 kilograms, embracing both the nitrogen and carbon of the ingesta and excreta, the following balance table may be given (Burdon-Sanderson):

Incomings.			Outgoings.		
Food.	N.	C.	Excreta.	N.	C.
100 gm. proteids . . .	15.5	53.	Urine	14.4	6.16
100 gm. fat	. .	79.	Feces	1.1	10.84
250 gm. carbohydrates	. .	93.	Respiration	. .	208.00
	15.5	225.		15.5	225.

The following is an instance of a balance table (Neumeister) of a man weighing 70 kilograms, showing nitrogenous equilibrium only, some of the carbon of the ingesta (mostly representing stored fat) not reappearing in the excreta:

Incomings.			Outgoings.		
Food.	N.	C.	Excreta.	N.	C.
137 gm. proteids . . .	19.5		Urine	17.4	12.6
117 gm. fat	. .	315.5	Feces	2.1	14.5
352 gm. carbohydrates	. .		Respiration	. .	248.6
	19.5	315.5		19.5	275.7

It has been found that, although work can be done on a non-nitrogenous diet, it does not follow that nitrogen is unnecessary. Experience has shown that nitrogen must be supplied when work is done, and that the amount must increase with the amount of work done. When no nitrogen is ingested the body uses some of its own nitrogen, and becomes fatigued after a small amount of work is performed.

Diet for Old Age.—König gives the minimum diet for an old man as follows: Proteids, 100 grams; fats, 68 grams; and carbohydrates, 350 grams. For an old woman he gives the following amounts: Proteids, 80 grams; fats, 50 grams; and carbohydrates, 260 grams. The food of the aged should be easily digested. With decreased physical energy the digestive powers are also lowered, and hence the nature of the food has to be regulated. Over-indulgence is especially to be avoided in the aged. Milk, grains, and fruit are well adapted for aged persons.

In an article on "Vegetarianism," A. Schoenstadt[1] states that: "There are two parties among vegetarians—the one excludes all animal nutritive materials of whatever nature, and the radical adherents live on only a few vegetables, namely, cereals, fruit, baked food, and water. The other party uses, besides vegetable food, also animal food materials which are obtained without killing the animals, as eggs, milk, cheese, butter, honey. This is really not vegetarianism, but a mixed diet."

Schoenstadt believes that it is possible to subsist on a purely vegetable diet, but states that it is not sufficient nor natural for man. He is of opinion that there is great danger connected with a vegetable diet:

a. Because the nutritive materials supplied are insufficient to meet the requirements of the organism.

b. Because this diet leads to grave digestive disturbances.

He regards this diet as insufficient for the inmates of institutions and prisons.

[1] *Deutsch. Vierteljahr. f. oefentl. Oesundheitspflege*, Bk. xxxii, S. 597.

Influence of Insufficient Food.—Deficiency in proteid materials in the dietary is attended with lessened activity and a general lowering of the vitality of the body. This adynamic condition favors the contraction of specific diseases. The omission of fats from the dietary results in illness in a few days. The body is unable to make up its carbon deficit from the other food-substances. Starch can be omitted from the dietary for a long time without detriment if fat is given. Deficiency in salts in the dietary is attended by malnutrition and a disorganized condition of the blood.

A form of deficient nutrition which was formerly quite common, and is still seen at times, is known as scurvy. This condition is brought about by a deficiency of fresh vegetables and fresh fruits, and sometimes to deficiency in fresh meats. It appears to be due to the absence from the dietary of certain organic acids and their salts.

Influence of Excessive Amounts of Food.—When much larger amounts of food are taken than can be utilized by the body the effects are manifested in dyspepsia, diarrhea, and gastro-intestinal irritation. Gout is a condition of the system in which the function of the liver and kidneys is disturbed because of long-continued efforts at eliminating excessive amounts of proteid materials ingested into the system. Excessive amounts of proteid material with deficient fat lead to wasting of the body-fat. Excessive amounts of fat and starch in the food lead to corpulency and disordered function of the digestive organs.

Nutritional Diseases.—Several diseases are now demonstrated to be due to faulty nutrition, though formerly one of these diseases was regarded as highly infectious—namely, beriberi.

Scurvy.—For a long time scurvy was a scourge on land and sea, but since the demonstration by Captain Cook in his voyage around the world that this disease could be prevented by including lemons in the dietary of sailors, we have learned that the disease can be prevented by limiting the quantity of salted meats in the dietary and adding

fresh vegetables and fruits, or even citric acid and vinegar. Scurvy is to-day a rare disease among civilized people.

Beriberi.—The disease develops because of the absence from the diet of some substance or substances necessary for the normal nutritive processes of the body, most commonly a diet consisting largely of polished rice. Strong and Crowell[1] have shown that the disease may occur in man under the most favorable hygienic conditions, with exception in regard to diet. Beriberi in man may be caused by limited diets which do not include polished rice, according to the observations of Alex Holst[2] on the occurrence of the disease on Norwegian ships; of Little[3] on the existence of beriberi on the coasts of Labrador and Newfoundland, where white wheat flour is the chief article of diet in certain seasons; and of Lovelace[4] as to the occurrence of cases in Brazil.

The observations of Fletcher[5] and Fraser and Stanton[6] have shown that diets consisting chiefly of polished rice are the common cause of beriberi in the Orient. The substitution of unpolished rice for polished rice eliminates beriberi. Gibson[7] found that the addition of calcium lactate to a polished-rice diet served to delay the onset of polyneuritis in fowls. Vedder and Clark[8] found that the addition of peas and peanuts to a polished-rice diet prevented the development of polyneuritis in fowls.

Beriberi was demonstrated by Baron Takaki to be due to the use of diet consisting largely of rice, and that it could be prevented by the addition of small quantities of meat and legumes to the dietary. It seems evident from the experimental study of the question that beriberi is caused by a diet deficient in some as yet unknown substance (vitamin) which is contained in the polishings

[1] *Philippine Jour. of Science*, Sept. 13, 1912, p. 271.

[2] *Jour. of Hygiene*, 1907, p. 619.

[3] *Jour. Amer. Med. Assoc.*, 1912, p. 2029.

[4] Ibid., p. 2134.

[5] *Lancet*, 1907, p. 1775.

[6] Ibid., 1909, p. 451.

[7] *Philippine Jour. of Science*, Sect. B, 1913, p. 351.

[8] Ibid., 1912, p. 423.

removed in the process of polishing, and that unpolished rice does not cause beriberi.

The nature of the substance removed from rice in the process of polishing has not been determined, but it is of great physiologic importance in the nutrition of the body. This substance is soluble in 0.3 per cent. hydrochloric acid, and is destroyed when heated to 120° C. for one hour. This substance is also soluble in water and in 91 per cent. alcohol.

Pellagra.—Lombroso and his followers have contended for many years that pellagra is due to an intoxication produced by poisons developed in spoiled corn through the action of certain micro-organisms which in themselves are harmless to man. Sambon[1] believes that the disease is due to a protozoal organism in all probability distributed by a species of Simulium, the sand fly in Europe. Niles[2] believes that the evidence in support of Sambon's belief is insufficient, and that the intoxication theory of Lambroso gives the most satisfactory explanation of the cause and character of the disease.

Goldberger[3] presented facts which indicated the relationship between diet and pellagra. The disease is not transmitted to nurses and attendants of patients in institutions. More recent investigations by Goldberger and his co-workers[4] have shown that the diet of the pellagrous families has a less liberal supply of animal proteins than that of non-pellagrous families living in the same neighborhood. There is no overconsumption of carbohydrates by the pellagrous families. The difference between the diets seems to be one of degree, not of kind. The diets of the pellagrous households have a smaller average supply of vitamins than do those of the non-pellagrous, lacking especially the fat-soluble factor.

[1] *Policlinico*, Rome, 1910, abstract *Jour. Amer. Med. Assoc.*, 55, 1910, 361.

[2] *Pellagra*, W. B. Saunders Co., 1912.

[3] The Etiology of Pellagra, *Pub. Health. Rep.*, 29, 1683, 1914.

[4] *Jour. Amer. Med. Assoc.*, 66, 471, 1916; *Pub. Health Report*, 30, 3117, and 3336, 1915; *Jour. Amer. Med. Assoc.*, 71, 944, 1918; *Bull. Hyg. Lab. U. S. P. H. S.*, Feb., 1920; *Pub. Health Rep.*, 35, 1920.

War Edema.—In certain zones during the World War large numbers of people suffered from edema due to diet deficient in protein and fats and very rich in carbohydrates. Rats fed on a carrot diet developed a similar condition. Kohman[1] experimented on rats with a diet consisting of carrots, cornstarch, fat (butter or lard), salts, and alcoholic extract of wheat germ. The carrots were the only source of protein. The rats developed marked edema. The substitution of 18 per cent. of pure casein for the cornstarch led to prompt recovery of the animal. These results indicate that the dropsy is due to deficient protein content of the food.

Vitamins are substances of unknown constitution, though probably of the nature of organic compounds, that are necessary for the normal growth and development and the continued normal functioning of the animal body. Two classes of vitamins have been recognized:

(*a*) Fat-soluble vitamins.

(*b*) Water-soluble vitamins.

The fat-soluble vitamin is contained in considerable quantities in cream, in leafy vegetables, in tomatoes, and in cod-liver oil. The supply of deficient quantities of fat-soluble vitamins is believed to lead to marked malnutrition in infants and children. Mellanby and others have attributed the development of rickets to lack of fat-soluble vitamins in the diet of children.

The water-soluble vitamin is of importance to nutrition in all stages of life. The prolonged use of diet deficient in water-soluble vitamin leads to diseased conditions, especially to beriberi and war dropsy. The water-soluble vitamin is contained in brewer's yeast and in smaller quantities in leafy vegetables, especially in spinach and cabbage. This factor is also found in tomatoes, in orange juice, in the inner peel of the orange, and in smaller quantities in apples and pears.

[1] *Proc. Soc. of Exp. Biol. and Med.*, xvi, 121, 1919.

CHAPTER VIII.

EXERCISE.

In order to maintain a perfect state of health of the body it is essential that each organ has a certain amount of exercise. All the bodily functions are attended with rhythmic motion, and these movements are facilitated by exercise. If there is deficient exercise of a portion of the body, continued for some time, the nutrition of this portion is impaired, the organs or members involved decrease in size and eventually degenerate in structure as well as in function. Overexertion of a portion of the body leads to abnormal nutrition and development of the organs or members involved, and if continued for some time degeneration may occur, which is as great as that resulting from disuse of the organs. It is essential, therefore, that the exercise is as uniform as possible for all the organs and members of the body so as to avoid over- or under-stimulation of any of its parts. Perfect health is dependent upon the uniform stimulation of all the functions, so that all the organs may be in a condition to act in their natural way and normal capacity.

The amount of energy expended in walking on a level is usually assumed to equal that required to lift one-twentieth of the body-weight through the distance walked. The most important effect of muscular exercise of any kind is produced on the lungs and circulation.

Effect on the Lungs.—Smith has found the effect of exercise on the amount of air respired, to vary in direct proportion with the amount of exertion. Taking the recumbent position as unity, he found the amounts of air inspired as follows:

Recumbent position	1.00	Walking and carrying 28.5 kg.	3.84
Sitting	1.18	Walking and carrying 53.5 kg.	4.75
Standing	1.33	Walking 4 miles per hour	5.00
Singing	1.26	Walking 6 miles per hour	7.00
Walking 1 mile per hour	1.90	Riding and trotting	4.05
Walking 2 miles per hour	2.76	Swimming	4.33
Walking 3 miles per hour	3.23	Treadmill	5.50
Walking and carrying 15 kg.	3.50		

Under ordinary circumstances a man inspires 8.5 liters of air per minute; if he walks 6½ kilometers, or 4 miles, per hour he inspires ($8.5 \times 4 =$) 34 liters; if he walks 9½ kilometers, or 6 miles per hour he inspires ($8.5 \times 6 =$) 51 liters. With increased amount of work there is an increased amount of carbon dioxid exhaled. The relative amount of carbon dioxid exhaled is greater, the larger the amount of work performed, on account of the increased oxidation because of the muscular exertion. Pettenkofer and Voit found the relative amounts of oxygen absorbed, and of carbon dioxid, water, and urea eliminated in rest and while at work to be as follows:

Weight of man experimented upon = 60 kilograms.	Absorption of oxygen in grams.	Elimination in grams of—		
		Carbon dioxid.	Water.	Urea.
Rest	708.9	911.5	828.0	37.2
Work	954.5	1284.2	2042.1	37.0
Excess and deficiency during work	245.6	372.7	1214.1	0.2

The increased amount of carbon dioxid eliminated during exercise indicates the necessity of an increased amount of carbon in the food of persons performing work requiring much muscular effort. This increased amount of carbon is best given in the form of fats, rather than in the form of starches. The increased elimination of water calls for an increased supply of water with the food, and especially as drink. It is preferable to take this in the form of plain water. Alcoholic beverages decrease the elimination of carbon dioxid by the lungs, and are therefore contraindicated

during muscular exercise. For this reason all alcoholic beverages are prohibited for athletes while in training.

Effect on the Circulation.—The first effect of exercise is to increase the rapidity and force of the heart action, causing increased blood-supply to the muscles, as well as to all the organs. Excessive exercise, when continued for some time, leads to irregular action of the heart, accompanied by great rapidity and disturbance of its rhythmic action. Such a condition is highly injurious, and calls for prompt cessation of the exercise.

Long-continued strenuous labor, or excessive exercise, leads to hypertrophy of the heart-muscle and increased caliber of the heart cavities. Such a condition, when once established, remains permanent. This condition is quite common in laborers who have performed unusually hard work for some years, in soldiers who have been obliged to take very long and forced marches, and in athletes who have been in hard training for some time.

On the other hand, deficient exercise leads to degeneration of the heart-muscle, weakening of the heart action and of the general circulation. In this condition there may be dilatation of the heart cavities without compensatory hypertrophy ; unusual deposition of fat on the outside of the heart, and even between the muscular bundles ; and fatty degeneration of the heart-muscle.

In beginning athletic training the heart action should be carefully noted in order to determine whether it is properly accommodating itself to the increased demands made upon it by the muscular exercise, as well as the manner in which it behaves during the period of rest after the exercise. After exercise the heart action gradually slows down and falls slightly below the normal. The extent to which the heart action falls below the normal indicates the amount of fatigue produced, as well as the compensating power of the heart.

With proper care, in healthy subjects, there is no great danger from athletic training. The amount of exercise taken should be gradually increased as the compensating

power of the heart increases with the demands made upon it. The athletic training should not be suddenly relinquished. The work should be lessened gradually, in order to allow the heart to accustom itself gradually to the decreased demands of everyday life.

Effect on the Muscles.—The result of repeated contraction and relaxation of any group of muscles is to cause an increase in the muscular fibers, with increased firmness and more active response to the will-power. The extent of growth is limited, however, and when the stimulation is long continued, or excessive, degenerative processes set in. Under such conditions the muscles become soft and flabby, and respond imperfectly and feebly to the will. During exercise there is increased temperature in the muscles, dependent to some extent upon the amount of work performed. There is an increased amount of carbon dioxid formed in the muscles as the result of the increased oxidation.

All the muscles of the body should be exercised as uniformly as possible. There is less likelihood of muscular degeneration, in certain groups of muscles, when the entire muscular system is required to do a certain amount of work. In training for any particular kind of athletic contest, in which certain groups of muscles are specially called into action, it is best to vary the exercise continually so as to keep all the muscles fully developed. For this purpose the training should be so conducted as to allow a period of rest to follow the special exercise, and then, before resuming the training, a short period of exercise in the gymnasium, or some simple athletic game, is advisable.

Fatigue.—As the result of muscular exercise there is a feeling of exhaustion and fatigue, amounting sometimes to actual pain in the tired muscles. This condition is brought about by the accumulation in the muscles of the products of their activity, especially paralactic acid, and to deficiency of oxygen. During the period of rest the accumulated products are eliminated and the supply

of oxygen is renewed. There is also a deficiency of water in the system as the result of excessive elimination, and this must be replaced. Since the bodily functions require the presence of a considerable amount of water in the system, it seems essential that during exercise the loss of water should be compensated by the administration of small amounts of water at short intervals. The fatigue of the muscular system can only be relieved by a period of rest. The heart-muscle, under ordinary work, has a rest between the contractions, which is about twice as long as the time consumed by the contractions, and hence it requires no additional rest to recover itself.

Effect on the Nervous System.—The effect of exercise on the nervous system is more indirect than direct in its nature. Moderate exercise assists in maintaining all the bodily functions in their normal condition, and hence the nervous system is in a position to act most efficiently. This fact has had abundant demonstration in recent years since athletic sports have become such an important feature in college life. It has been found that, as a rule, the best athletes are rather above the average in their class records.

Overtraining is of course detrimental to the nervous system, because it undermines the general health. The effect of active exercise upon the mental activity is dependent to a certain extent upon individual conditions; but, as a rule, it is believed to be perfectly allowable in students that are able to keep up with the majority of their class. It is better to attain somewhat lower averages in class standing than to risk a breaking down of the nervous system as the result of overstudy or injury of the general health, because of too close application to study.

Effect on the Elimination of Nitrogen.—A large number of experiments have been made to determine the relative amounts of nitrogen eliminated during rest and exercise. The results obtained indicate that during exercise the amount of nitrogen assimilated is increased per-

ceptibly. The metabolism of nitrogen is influenced somewhat by the period of work and rest, and the severity of the work performed. During a period of active exercise the amount of nitrogen eliminated from the kidneys is slightly diminished, and after the exercise there is a slight excess of nitrogen excreted, continuing for some time. During severe exercise the amount of nitrogen eliminated appears to be increased. Voit and Krummacher are of the opinion that usually work does not directly produce a greater breaking down of proteid matter, but that an increase in the proteid cleavage is caused by the increased combustion of the nitrogen-free materials which protect the proteid matter. If it were possible, during the period of work, to supply the cells continuously with a sufficient amount of nitrogen-free material, then there would be no increase in the quantity of proteid material broken down. But this is a very difficult matter. Krummacher believes that the after-effect of muscular labor is not due to the continued excretion of nitrogenous cleavage-products, but to the fact that the nitrogen-free materials in the body were used up, and that it takes some time to provide the body with a new supply. In active exercise, therefore, an increased amount of nitrogen must be supplied in the food, as well as an increased amount of carbon. There must also be an increased supply of salts, especially sodium chlorid and potassium phosphate, to supply the loss in these salts during exercise.

Amount of Exercise that Should be Taken.—A good day's work for an average man is considered to be 150,000 kilogram-meters. Haughton has shown that walking on a level surface at the rate of 3 miles (4.8 kilometers) per hour is about equal to raising one-twentieth of the weight of the body through the distance walked.

In order to determine the work performed in walking 32,000 meters per day, we multiply the weight of the body in kilograms by the distance travelled, the result being the kilogram-meters of work performed. If a

pedestrian walks 32,000 meters a day, without a load, the energy expended, assuming him to weigh 70 kilograms, is $32{,}000 \times 70 = 2{,}240{,}000$ kilogram-meters. Haughton divides the work performed into "fatigue work," the effort necessary to carry the weight of the body, and "useful work," the energy expended in performing labor. For instance, Coulomb observed that the work done by porters employed to carry goods 2000 meters, returning unloaded, amounted to 348 kilograms in six journeys, or 58 kilograms at a time. The useful work performed was, therefore, $2000 \times 348 = 696{,}000$ kilogram-meters; the fatigue work was $2000 \times 2 \times 70 \times 6 = 1{,}680{,}000$ kilogram-meters. This allows 70 kilograms as the weight of the porter, and takes into consideration that the body is carried in both directions, or 4000 meters. The total energy expended was 2,376,000 kilogram-meters. He also found that pedlars, who always travelled loaded with their packs, were able, with a load of 44 kilograms, to travel 19,000 meters per day. Assuming their weight of 70 kilograms, we find—

$19{,}000 \times 44 = 836{,}000$ kilogram-meters = useful work.
$19{,}000 \times 70 = 1{,}330{,}000$ kilogram-meters = fatigue work.
Total = 2,166,000 kilogram-meters.

The energy expended under the foregoing conditions was, then,

Man walking without a load........	32,000 meters—	2,240,000 kgm.-meters.
Man alternately loaded and unloaded	24,000 "	2,376,000 "
Man loaded all day................	19,000 "	2,166,000 "

In athletic exercises it is essential that the amount of energy expended be carefully determined, in order to ascertain whether the exercise is likely to prove beneficial or otherwise. The amount of energy expended in athletic sports should not exceed that expended by laborers in hard manual labor. In athletic contests, of course, the energy expended is often in excess of this amount; but a period of comparative rest must follow the contest, in order to allow the body to recuperate from the fatigue

16

induced by the contest. The harmful effects of the large amount of energy expended in some athletic contests is frequently seen when these contests take place at too short intervals, allowing insufficient time for the contestants to recover from the fatigue of the previous contest. The same effects are also noted in soldiers who are compelled to make frequent forced marches over long distances.

From what has been learned of the effects of exercise, it will be seen that athletic training should aim to increase the breathing-power; to strengthen the power of the heart's action; to make the muscular action more vigorous and enduring; and to decrease the amount of fat. These results are obtained by careful dieting; by regular and systematic exercise; and by increasing the action of the eliminating organs, especially the skin.

Persons following sedentary occupations are especially prone to neglect taking exercise, and hence are not in good physical condition. Those who do not have time to engage in exercise or in sports, as walking, riding, swimming, or playing ball or golf, should resort to systematic daily exercises, as calisthenics or setting-up exercises, so as to keep the muscles of the body in good tone.

CHAPTER IX.

CLOTHING.

THE function of clothing is to protect against the weather—heat, cold, and dampness—and to protect against injury. All other uses of clothing have no direct hygienic interest, only indirectly in so far as they may be injurious to health.

Protection against Cold.—The most important use of clothing in cold climates is to protect against cold. Clothing serves this purpose by diminishing the radiation of heat from the body. The radiation of heat from the body diminishes with the number of layers of clothing worn, and is also dependent upon the nature of the clothing worn. If we take the amount of radiation of heat from the naked body as 100, the radiation is reduced to 73 by means of a woollen shirt; to 60 by means of both a woollen and a linen shirt; to 46 by means of a woollen and a linen shirt and a vest; to 33 by the addition of a coat. Rubner found that if the radiation at 15° C. is taken as 100, at 23° C. it is only 69, at 29° C. it is 56, and at 32° C. it is 31.

The radiation of heat is directly dependent upon the thickness of the layer of clothing. If we take the loss of heat as 100, a thickness of 1 millimeter of cotton allows a radiation of 77 per cent.; 2 millimeters, of 68 per cent.; 3 millimeters, of 65 per cent.; 4 millimeters, of 57 per cent.; 5 millimeters, of 53 per cent.; 10 millimeters, of 41 per cent.; 15 millimeters, of 30 per cent.

The thickness of clothing, in our climate, must not be so great as to increase perceptibly the air-pressure by compression, nor so thin as to decrease perceptibly the air-pressure. The thickness of the clothing is, therefore,

one of the most important features. The radiation of heat from the body is very nearly the same whatever the nature of the clothing. Wool, silk, and cotton are equally warm when thickness of the layer is the same. The most rational clothing, however, is that which conserves the heat of the body with the least quantity of material. Flannel would be the lightest and warmest; but, since it wears so rapidly, woollen cloth is more serviceable, because it wears better. The smoothly woven cloths are not so warm as the tricot cloths, but they are more serviceable.

The clothing should not only be light, but it should functionate well with regard to the absorption of moisture from the skin. It should take up the moisture as readily as possible, and should quickly dry out. For this reason the clothing worn next the body should be porous, so that all the pores may not be filled with perspiration. Closely woven goods is not adapted for this purpose. Some authorities claim that linen, of coarse mesh, is best adapted for this purpose because it does not retain the moisture as long as wool.

Protection against Heat.—The degree of porosity is an important feature in summer clothing. The color of summer clothing is also important. Dark clothing absorbs heat to some extent, and in consequence it is somewhat warmer than white fabrics or those of lighter colors. The degree of porosity is, however, the most important factor, because on this property depends the interchange of air through the skin. The effect of the direct radiation of heat from the sun may be inhibited in part by a proper covering of the head. For this purpose straw hats with broad brims are most serviceable. They shade the head and face, and allow free ventilation of the scalp, with a layer of air between the head and the covering. This is important, because air is a poor conductor of heat.

Protection against Dampness. — During rainy weather the use of some impervious material serves to exclude the dampness from the body and clothing. Damp

clothing is injurious not only because it is liable to produce chill, but because it prevents the free evaporation of heat and moisture from the surface of the body. The importance of keeping the clothing dry in rainy weather is therefore self-evident.

Protection against Injury.—Clothing protects the body against mechanical injury, from frost, or from the direct rays of the sun. Among civilized peoples protection of the feet is also necessary to avoid injury or annoyance in walking over rough ground. The sole of the shoe should conform to the shape of the foot. This

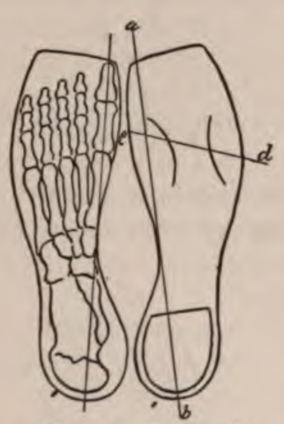


FIG. 46.—Correct sole (Hueppe).

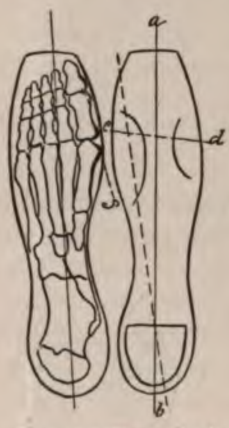


FIG. 47.—Shoemaker's sole (Hueppe).

is of the greatest importance. The length of the sole is the so-called Meyer line (Fig. 46, *ab*), which extends from the middle of the heel through the middle of the great toe, and lies parallel with the inner border of the anterior half of the foot. The breadth of the sole is indicated by the Starck line (Fig. 46, *cd*), which extends diagonally from the head of the first metatarsal bone to form the letter V. The shoemaker's sole is usually cut so that the shoe is symmetrically divided right and left by a line extending through the middle, and which commonly corresponds to the anatomical axis (Fig. 47). As the result

of wearing shoes with soles of this pattern we have subluxations of the great toe at *s*, whereby the latter is

FIG. 48.—Normal feet (Whitman).

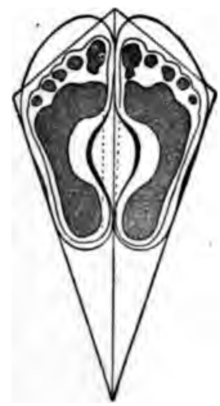


FIG. 49.—Proper soles for normal feet (Whitman).

forced outward and increases the prominence of the ball of the great toe. This decreases the room for the other

FIG. 50.—Deformed feet (Whitman).

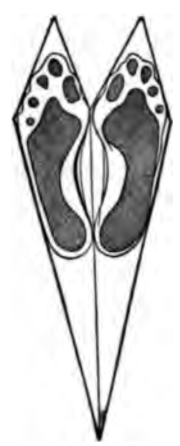


FIG. 51.—Shoemakers' soles (Whitman).

toes, and, in consequence, these are superimposed upon each other, instead of lying side by side.

Figs. 48, 49, 50, and 51 also give the outlines of

normal feet and the manner in which these normal outlines are deformed by the universal soles of the shoemaker. It will be seen that the shoemakers' soles, as figured by Whitman, in no way conform to the outlines of normal feet.

The heels should be low, broad, and long, so as to afford proper support to the body. High heels are especially injurious, because they place the larger part of the weight of the body on the ball of the foot. The shoes should not be so tight as to compress the feet. Laced shoes are the most rational, because they can be fastened to the feet in such a manner as to allow the least amount of friction. Rubber shoes should be worn only for a short time during wet weather, and should be removed as soon as they are not needed.

Injurious Effects of Clothing.—The clothing should be of such a pattern as to conform to the natural shape of the body without constricting or compressing any portion thereof. With regard to the covering of the feet, this point has already been discussed. Above all, there should be no constriction of the chest and abdomen. The abdominal organs and the lungs and heart should be as free to act as possible. The clothing worn by men is quite rational with this respect, but that worn by women, in general, is most irrational. The wearing of corsets is highly injurious, as has been frequently proved, and it is unnecessary to adduce facts to prove the statement. Corsets compress the chest and abdomen, thus impeding respiration and the movements of the heart. The abdominal organs and muscles are also compressed and correspondingly deformed and interfered with in their normal functions. The use of tight garters is also injurious. The clothing of women should be suspended from the shoulders, and not from the hips, in order to diffuse the weight more evenly.

The wearing of heavy head-coverings is also injurious, because it places a constant weight upon the spinal column. The use of veils is especially injurious, because of the obstructed vision which they induce. The com-

bination head-covering worn by women in mourning is injurious, and frequently leads to persistent nervous trouble, as well as to general fatigue from its weight. It is not unusual to see spinal curvature follow prolonged wearing of the head-covering fashionable in mourning.

Reforms in dress are quite difficult to bring into effect, especially if they are opposed by ancient custom as well as by modern fashion. As long as a form of dress is fashionable it is difficult to induce any one to relinquish it, no matter how injurious it may be or how desirable the change from a hygienic point of view.

Cleanliness in Relation to Clothing.—The excretions of the body through the skin are absorbed by the clothing, and consequently frequent changes should be made to prevent injurious effects from the accumulation of these products in the clothing. The excretions of the body fill the pores of the clothing and render it more impervious, and therefore less suited for the interchange of air. This is especially the case in those engaged in laborious work, where the amount of perspiration is great.

Starching and ironing tend to close the pores in clothing and render it more impervious. The wearing of unstarched clothing in hot weather is, therefore, more comfortable. In winter starching and ironing serve to conserve the heat of the body.

The amount of clothing worn must be varied with the season of the year and the sensations of each individual. The amount of clothing necessary to conserve the heat of the body of one person may be entirely too light or too heavy for another. The changes from lighter to heavier clothing, and *vice versa*, should not be made too suddenly. In localities where there is a variable climate, with frequent changes in the temperature and humidity of the atmosphere, as is the case in the northern States during spring and autumn, the change from heavy to light clothing, and *vice versa*, must be made with great circumspection, in order to prevent the development of catarrhal diseases. The changes must be made accord-

ing to the idiosyncrasies of the individual and the season of the year. The change can never be regulated by the calendar, because the conditions vary perceptibly from year to year. The time of the year when the changes may be made with safety must frequently become a question for the physician to decide for those under his care, because of his larger experience in questions of this nature on account of prolonged observation and study.

Infected Clothes and Bedding.—Viola and Morella have recently published the following conclusions, based upon their experiments:

Clothing, linen, and other garments are capable of holding a relatively large number of micro-organisms, varying from 915 to 571,962 for each square centimeter of goods. While the greater part of these bacteria are saprophytic, pathogenic germs are also found. The number of bacteria found in garments in actual contact with the human body is in direct ratio to the number of days the garments are worn. In general, the number of bacteria found in clothing of a person is proportional to the activity of his occupation. Wool has a greater capacity for germs than cotton or silk. Corresponding to the local bacteriologic flora of the surface of the human body, there is a quantitative difference in the bacterial contents of clothing covering different parts of the skin. In clothing actually being worn, pathogenic bacteria live a shorter time than in the same garments hanging in a wardrobe. Under all conditions pathogenic bacteria contained in clothing gradually die out. There is, with the passage of time, a gradual diminution in the number of disease-producing germs with which a given article of clothing has been contaminated. There is also a progressive decline in the power of development of bacteria, as they undergo a gradual diminution in virulence. The authors conclude that garments are a potent means for the diffusion of infectious agents, and that without special treatment pathogenic germs can retain their virulence in human raiment for a considerable but not indefinite period.

CHAPTER X.

PERSONAL HYGIENE.

PERFECT health is dependent upon the normal activity of all the organs of the body. The organic functions of the body can be maintained in their normal condition only by observing all the general hygienic rules and regulations. These principles, while they are well recognized and of the utmost general value, cannot, however, be stated in very specific terms when applied to individual conditions, because the individual idiosyncrasies of different persons vary to such a great extent.

There must be continuous moderation in **diet,** both with regard to quality and quantity. The individual peculiarities as produced by inherited and acquired instincts influence the quality and quantity of food that are most suitable. The nature and amount of work performed is also an important factor in the matter of diet. So also are the temperature, latitude, and altitude of a locality, and the amount and nature of the clothing worn. Individual experience, therefore, plays a most important part in governing the diet of each person. The point to be borne in mind is that all excesses should be avoided. No more should be taken than the system demands and can conveniently utilize. If this point is properly regulated, one of the principal factors in the production of disease is eliminated. The food taken should be slowly and thoroughly masticated. This will favor the admixture of a plentiful supply of saliva, and will also facilitate the subsequent steps in the process of digestion. Proper mastication of the food cannot take place without sound teeth. Defective teeth frequently lie at the foundation of various affections of the stomach.

The supply of nitrogenous and carbonaceous foods should be regulated according to the demands of the body. If there is a deficiency of fatty deposit, the supply of carbohydrates is probably insufficient; on the other hand, if there is an excess of fatty deposit, the supply of fats and carbohydrates is excessive. These are points that can be regulated by each individual, to a certain extent, though it must be remembered that some persons are normally fatter or thinner than others.

Cleanliness is one of the most important factors in the preservation of health. This applies not only to cleanliness of the body, but to cleanliness in every particular of life. It goes without saying that cleanliness of body, clothing, and habitation are essential to good health. The number of baths taken, and the kind of bath, is a matter that is governed by individual conditions, such as habit, amount and character of the work performed, and the temperature of the locality.

Regular attention to **the bowels** is an important matter in regulating the health. The number of movements a day will be regulated by the diet and habit of each individual, though it is generally conceded that one movement a day is desirable in order to maintain the efficiency of the digestive apparatus.

The regulation of **the passions** is another matter for individual control, though all excesses should be avoided. The practice of vices is to be condemned in the most forcible manner because of the detrimental influence upon the nervous system and the entire organism. Parkes states that "we know that a widespread profligacy has eaten away the vigor of nations, and caused the downfall of nations; but we hardly recognize that, in a less degree, the same causes are active among us, and never realize what a State might be if its citizens were temperate in all things."

Cleanliness of **the mouth and teeth** is of the greatest importance. Proper care of the teeth, including systematic cleansing, will go far to preserve them in a

sound condition. This will also serve to prevent the accumulation of decaying food particles around the teeth and gums, and thus prevent the decay of the teeth and disease of the gums and of the mucous membrane of the mouth and throat. A decaying tooth should be filled as early as possible, in order to preserve it and to prevent more serious disease of the maxillary bone.

Great care should be exercised in the selection of a **habitation.** The nature of the water-supply is an important factor in the preservation of health. If the purity of the water-supply is doubtful, it will be the wisest course to have all the water boiled. The nature of the soil is also an important factor. Damp soils, as well as recently made soils, should be avoided, because they may prove injurious to health. The material used in constructing the house is of importance, as well as the position of the house with reference to the points of the compass. A southern exposure is usually preferable to a northern exposure. The number and arrangement of the windows should be considered. There should be plenty of light and free access of air. Sunlight is the great restorer and purifier, and it should be freely admitted to all houses when the temperature will permit.

The nature of the **occupation** and its influence upon health should be carefully considered. If the occupation selected should prove detrimental to health, it should be discarded for one that is less likely to operate in the same manner. If a sedentary occupation proves harmful, it should give way to another involving much outdoor activity. The amount of mental work that may be performed without injuring the health will depend upon the individual constitution. A sedentary occupation may be prevented from injuring the health by the employment of systematic exercise of some form or another. Whenever possible the occupation, as well as the bodily exercise, should be of a cheerful nature. The exercise indulged in may often be made most beneficial by taking it in conjunction with other persons. For this reason the

different athletic sports are of such great benefit. If outdoor exercise be taken, it may be made profitable as well as pleasurable by combining it with nature studies. Under such conditions the exercise is not so likely to become burdensome, because one loses sight of the feeling of compulsion.

The **mental attitude** of the individual is also an important factor in preserving health. Hopefulness and cheerfulness are great aids to health because of their beneficial influence on digestion. The mental condition is largely under the control of the will-power, and each individual is hopeful and cheerful or morose and despondent as he wills to be.

The regulation of work, rest, sleep, and meals is more or less under individual control. The amount of sleep required for perfect refreshment varies with the individual. It is usually greater in childhood and old age than in the prime of life. The amount of sleep taken in order to preserve the health should be sufficient to prevent, if possible, a feeling of sleepiness during the day. It is generally conceded that the most refreshing sleep is obtained in the early hours of the night, though some persons can accustom themselves to sleep soundly during any portion of the twenty-four hours. It is possible to deprive one's self of sleep for a considerable time, but eventually the effects will be felt in loss of nervous power. This is especially the case with those engaged in mental work. Sooner or later a period of insomnia supervenes which is not easily overcome.

CHAPTER XI.

INDUSTRIAL HYGIENE.

INDUSTRIAL hygiene received very little attention in the United States until about 1910. Since that time a number of important investigations have been made of the occupational hazards in various industries, and the results of these investigations have been published in the form of bulletins by the Department of Labor, by State Boards of Health, and in the form of text-books, notably those of G. Gilman Thompson, "Occupational Diseases"; George M. Price, "The Modern Factory"; E. R. Hayhurst, "Industrial Health-hazards and Occupational Diseases of Ohio"; George M. Kober and Wm. C. Hanson, "Diseases of Occupation and Vocational Hygiene."

The rapidity with which this literature has been published is an indication of the increasing importance of the subject of Industrial Hygiene as a public health problem. The European War has made the entire subject one of the most important now before the industrial, commercial, and medical world.

The influence of occupation upon the health of laborers is a subject of the greatest hygienic importance. Certain occupations are far more dangerous than others because of the liability to accident; some occupations are more dangerous than others because of poisonous fumes and gases that are given off in certain manufacturing proc-

esses; again, other occupations are dangerous to health because of various kinds of dusts that are produced, thus leading to irritation of the respiratory organs. In other occupations certain groups of muscles and certain organs of the body are used excessively, thus leading to defects in these organs; while in others a constrained attitude is maintained while at work, or a sedentary life is induced, which may be the cause of ill health.

According to Hayhurst the most important industrial health-hazards are: Dust, dirt, darkness, dampness, devitalizing air, heat, cold, fatigue, inactivity, infection, poisons, compressed air, foul odors, venereal diseases, and stimulation. At the present time the most important health-hazards in industrial establishments are various forms of dust, different kinds of poisons, and accidents. All of the industrial health-hazards are preventable and many of them can be prevented through the education of the laborers so as to get them to realize the hazards encountered and the measures to be adopted to make their work reasonably safe.

The occupations which are directly concerned in the production of disease are those in which irritating or poisonous gases are produced, such as sulphurous, nitric, and hydrochloric acid fumes; ammonia, chlorin, carbon monoxid and dioxid, hydrogen sulphid and carbon disulphid, iodin, bromin, and phosphorus vapors; turpentine and petroleum vapors; mercury, arsenic, lead, zinc, and copper poisoning; aniline vapors; those in which irritating or poisonous dusts are produced, such as coal-dust, metallic dust of various kinds, mineral dust, and vegetable dust; those in which there is local absorption of irritating or poisonous substances, such as arsenic, phosphorus, quinin, potassium bichromate, strong alkalies, and petroleum; those in which there is an elevated or variable temperature and atmospheric pressure.

Analyses of the deaths occurring in the different

occupations have given us a knowledge of the relative degree of danger from different forms of industrial pursuits. Such an analysis has been made of all the deaths occurring in Massachusetts, including all persons over twenty years of age, from May 1, 1843, to December 31, 1885, by the registration bureau of that State. The following table gives the detailed results of this analysis. The total number of deaths was 229,897, and the average age at death 51.82 years :

Occupations.	Number of persons.	Average age at death.
Class I. Cultivators of the earth : Farmers, gardeners, etc.	46,182	66.29
Class II. Active mechanics abroad.	17,371	51.34
Brickmakers	159	49.71
Carpenters and joiners	9,761	55.06
Calkers and gravers	281	58.91
Masons	2,889	53.33
Millwrights	188	60.43
Riggers	237	55.54
Ship-carpenters	1,305	61.36
Slaters	159	41.69
Stone-cutters	1,678	41.22
Tanners	714	52.73
Class III. Active mechanics in shops.	28,208	48.80
Bakers	751	49.16
Blacksmiths	3,615	55.11
Brewers	63	45.14
Cabinet-makers	1,250	50.66
Calico-printers	16	58.87
Cord-makers	52	50.42
Carriage-makers and trimmers.	479	51.87
Chair-makers	234	46.49
Clothiers	119	57.25
Confectioners	171	45.37
Cooks	243	40.87
Coopers	1,299	59 88
Coppersmiths	150	46.09
Curriers	951	45.79
Cutlers	218	42.01
Distillers	36	58.78
Dyers	269	48.65
Founders	764	44.82
Furnace-men	175	46.28
Glassblowers and glass-makers.	202	41.61
Gunsmiths	306	50.35
Hatters	530	34.55
Leather-dressers	354	46.88
Machinists	3,761	43.47
Millers	386	58.69
Musical instrument makers.	61	49.25
Nail-makers	279	45.75
Pail- and tub-makers	7	41.86
Painters	3,561	45.77
Paper-makers	463	48.65
Piano-forte makers	210	48.30
Plumbers	303	36.34
Potters	65	58.02
Pump- and block-makers	124	58.23
Reed-makers	18	45.94
Rope-makers	371	60.01
Tallow-chandlers	115	56.75
Tin-smiths	640	42.95
Trunk-makers	78	40.38
Upholsterers	287	40.98
Weavers	971	44.65
Wheelwrights	738	59.50
Wood-turners	154	49.54
Mechanics (trade not specified).	3,369	47.35
Class IV. Inactive mechanics in shops.	28,459	45.43
Barbers	772	39.34
Basket-makers	109	60.32
Book-binders	258	43.56
Brush-makers	96	47.36
Carvers	141	37.60
Cigar-makers	306	39.78
Clock- and watch-makers	205	51.47
Comb-makers	222	54.09
Engravers	200	39.74
Glass-cutters	124	44.40
Harness-makers	676	50.00
Jewellers	782	41.62
Operatives	4,662	41.28
Printers	1,243	40.58
Sail-makers	310	55.17
Shoe-cutters	795	47.06
Shoe-makers	14,802	46.34
Silversmiths or goldsmiths.	140	48.59
Tailors	2,174	50.19
Tobacconists	61	50.41
Whip-makers	143	44.50
Wool-sorters	238	48.92
Class V. No special trades.	43,716	49.06
Laborers	42,532	49.16
Servants	624	39.15
Stevedores	123	54.07
Watchmen	410	53.13
Workmen in powder-mills.	27	37.41

Occupations.	Number of persons.	Average age at death.
Class VI. Factors, laboring abroad, etc.	10,776	39.36
Baggage-masters	72	36.25
Brakemen	509	27.12
Butchers	888	50.50
Chimney-sweepers	4	34.50
Drivers	681	40.36
Drovers	28	51.32
Engineers and firemen	1,170	41.57
Expressmen	448	44.18
Ferrymen	11	51.27
Lighthouse-keepers	24	60.24
Peddlers	770	48.28
Sextons	149	60.01
Soldiers	2,926	28.59
Stablers	654	44.66
Teamsters	2,370	42.31
Weighers and gaugers	39	57.72
Wharfingers	33	55.48
Class VII. Employed on the ocean.	12,394	48.57
Fishermen	965	44.37
Mariners	11	44.36
Naval officers	90	52.82
Pilots	122	61.63
Seamen	11,206	48.76
Class VIII. Merchants, financiers, agents, etc.	27,098	49.60
Agents	752	50.62
Bankers	103	59.73
Bank officers	243	57.10
Boardinghouse-keepers	127	50.47
Booksellers	104	54.75
Brokers	382	52.13
Clerks and bookkeepers	6,449	36.35
Druggists and apothecaries.	487	43.86
Gentlemen	1,993	68.87
Grocers	1,019	48.80
Innkeepers	734	51.63
Manufacturers	2,219	54.92
Merchants	6,200	56.45
Newsdealers or carriers	76	43.78
Railroad agents or conductors.	561	41.28
Saloon- and restaurant-keepers.	832	40.70
Stove-dealers	26	47.46
Telegraphers	59	29.97
Traders	4,732	50.39
Class IX. Professional men.	8,306	52.13
Actors	68	42.18
Architects	71	46.23
Artists	306	45.41
Civil engineers	188	43.91
Clergymen	1,560	60.31
Dentists	193	45.47
Editors and reporters	187	46.50
Judges and justices	46	66.17
Lawyers	1,017	56.41
Musicians	419	43.13
Photographers	66	43.79
Physicians	1,804	56.51
Professors	68	58.44
Public officers	637	56.44
Sheriffs, constables, and policemen.	407	52.30
Students	460	23.67
Surveyors	125	54.10
Teachers	694	44.62
Class. X. Females	7,387	39.19
Domestics	1,990	44.11
Dress-makers	595	42.35
Milliners	230	42.45
Nurses	291	62.62
Operatives	2,237	29.71
Seamstresses	476	47.25
Shoe-binders	89	36.78
Straw-workers	123	35.08
Tailoresses	353	51.71
Teachers	985	33.72
Telegraphers	18	27.39

This table is not accurate in all its details, and also fails to present the relative healthfulness of different occupations, because persons are constantly changing from one occupation to another. It shows, however, very clearly the relation of certain occupations to longevity.

Dr. William Ogle, who has probably given more attention to this subject than anyone else, in a paper presented to the Seventh International Congress of Hygiene, 1891, on mortality in relation to occupation, states that "of all the various influences that tend to produce differences of mortality in different parts of a given country, there is none so potent as the character of the prevailing

occupations." He states further that "the only method of making death-rates that can be safely compared with each other is the laborious plan of calculating the death-rates for each occupation at each successive age-period, and then applying these successive death-rates to a population with precisely the same age-distribution in each industry. This method, indeed, is necessary, not only when the mortality of an occupation is being compared with that of any other, but generally in all comparisons of mortality, as, for instance, in comparison between the mortalities of different countries, or between the mortalities of the two sexes. It is, however, a method which, owing to its laboriousness, is rarely used, with the necessary consequence that many very erroneous comparisons are made."

He gives the mortality in different industries and professions which were derived from a comparison between the census returns of England for 1881 and the death-registers for the three years 1881, '82, and '83. The figures relate exclusively to males.

The lowest death-rate obtained was that of men in the clerical profession, and for the sake of comparison this is taken as the standard, being represented by 100, and the death-rate of each of the other professions or industries is represented by a figure proportionate to this standard.

Dr. Ogle classes the causes of high mortality under seven general headings:

"1. Working in a cramped or constrained attitude, and notably in such an attitude as cramps the chest and interferes with the action of the heart and lungs.

"2. Exposure to the action of special poisonous or irritating substances, such as phosphorus, mercury, lead, infected hair or wool, soot, etc.

"3. Excessive work, mental or physical.

"4. Working in confined spaces and in foul and over-heated air. This is probably, in the aggregate, one of the most destructive agencies in operation, because of the very large number of trades that are exposed to it.

Comparative Mortality of Men, Twenty-five to Sixty-five Years of Age, in Different Occupations, 1881, 1882, *and* 1883.

Occupation.	Comparative mortality.	Occupation.	Comparative mortality.
Clergymen, priests, ministers	100	Builders, masons, bricklayers	174
Lawyers	152	Carpenters, joiners	148
Medical men	202	Cabinet-makers, upholsterers	173
Gardeners	108	Plumbers, painters, glaziers	216
Farmers	114	Blacksmiths	175
Agricultural laborers	126	Engine-, machine-, boiler-makers	155
Fishermen	143	Silk manufacture	152
Commercial clerks	179	Wool, worsted, manufacture	186
Commercial travellers	171	Cotton manufacture	196
Innkeepers, liquor dealers	274	Cutlers, scissor-makers	229
Inn, hotel service	397	Gunsmiths	186
Brewers	245	File-makers	300
Butchers	211	Paper-makers	129
Bakers	172	Glass-workers	214
Corn-millers	172	Earthenware-makers	314
Grocers	139	Coal-miners	160
Drapers	159	Cornish miners	331
Shopkeepers generally	158	Stone, slate quarries	202
Tailors	189	Cab, omnibus service	267
Shoe-makers	166	Railway, road, laborers	185
Hatters	192	Costermongers, hawkers, street-sellers	338
Printers	193		
Book-binders	210		

"5. Excessive use of alcoholic beverages.

"6. Liability to fatal accident.

"7. Exposure to inhalation of dust."

Under the second cause Dr. Ogle gives the following table of the comparative mortality from lead-poisoning, based on the death-register for 1879–82, in males over fifteen years of age:

File-makers	466	per million living.
Painters, plumbers, glaziers	224	" "
Earthenware-makers	152	" "
Gas-fitters	62	" "
Printers	27	" "
All other males	4	" "

Under the fourth cause he gives the following table, showing the effects upon the lungs alone, though the lungs are not the only organs affected by this cause. Fishermen, who suffer least from these diseases, are taken as the standard, and the mortality for this occupation is represented as 100.

Comparative Mortality from Phthisis and Lung Diseases of Men (Forty-five to Sixty-five Years) Working in Pure and Vitiated Air.

Air.	Occupation.	Phthisis.	Diseases of respiratory organs.	Phthisis and diseases of the respiratory organs.
Pure air	Fishermen	55	45	100
	Farmers	52	50	102
	Gardeners	61	56	117
	Agricultural laborers	62	79	141
Confined air	Grocers	84	59	143
	Drapers	152	65	217
Highly vitiated air	Tailors	144	94	238
	Printers	233	84	317

Under the fifth cause he gives the comparative mortality from various diseases of liquor-dealers and men generally. The trade most exposed to the effects of the excessive use of alcohol is that of dealers in these beverages—"innkeepers, publicans, and wine- and spirit-dealers." The table shows the comparative results obtained by taking the mortality of 1000 males of corresponding ages.

Under the seventh cause he gives the comparative mortality from phthisis and lung diseases in the various dust-inhaling occupations. The effects of the inhalation of dust are shown in an increased mortality from phthisis and from lung diseases, though the effects differ very greatly, not only with the amount of dust, but also with the character of the dust, the more irritating the dust the more injurious its effects.

Comparative Mortality of Liquor-dealers and Men generally.

Diseases.	Men twenty-five to sixty-five years of age.	
	Liquor trade.	All males.
Alcoholism	55	10
Liver diseases	240	39
Gout	13	3
Diseases of the nervous system	200	119
Suicide	26	14
Diseases of the urinary system	83	41
Diseases of the circulatory system	140	120
All other causes	764	654
All causes	1521	1000

Comparative Mortality from Phthisis and Respiratory Diseases of Men in various Dust-inhaling Occupations.

Men twenty-five to sixty-five years of age.	Phthisis.	Lung diseases.	Phthisis and lung diseases.
Fishermen (as standard).	55	45	100
Carpenters, joiners	103	67	170
Bakers	107	94	201
Wool-workers	130	104	234
Cotton-workers	137	137	274
Cutlers, scissors-workers	187	196	383
File-workers	219	177	396
Masons, bricklayers	127	102	229
Stone and slate quarrymen	156	138	294
Pottery-makers	239	326	565
Cornish miners	348	231	579
Coal-miners	64	102	166

"The dust of ordinary kinds of woods, such as are commonly used by carpenters and joiners, appears to have very little, if any, injurious effect upon the air-passages, for the mortality of these artisans, both from phthisis and from diseases of the respiratory organs, is below the average for males generally. The harder woods, however, such as are used by cabinet-makers, are said to give off a much more injurious dust than do the softer woods used by carpenters."

The following tables are based on statistics gathered

from the mortality experience of the industrial department of the Metropolitan Life Insurance Co., 1911 to 1913:

TABLE A.—*Average Age at Death, by Occupation, Males.*

	Average age at death.
Bookkeepers and office assistants	36.5
Enginemen and trainmen (railway)	37.4
Plumbers, gas fitters, and steam fitters	39.8
Compositors and printers	40.2
Teamsters, drivers, and chauffeurs	42.2
Saloon keepers and bartenders	42.6
Machinists	43.9
Longshoremen and stevedores	47.0
Textile mill workers	47.6
Iron molders	48.0
Painters, paperhangers, and varnishers	48.6
Cigarmakers and tobacco workers	49.5
Bakers	50.6
Railway track and yard workers	50.7
Coalminers	51.3
Laborers	52.8
Masons and bricklayers	55.0
Blacksmiths	55.4
Farmers and farm laborers	58.5
All occupations	47.9

TABLE B.—*Average Age at Death, by Occupation, Females.*

	Average age at death.
Clerks, bookkeepers, and office assistants	26.1
Store clerks and saleswomen	28.0
Textile mill workers	33.9
Dressmakers and garment workers	42.0
Domestic servants	49.1
Housewives and housekeepers	53.3
All specified occupations	51.1

The figures for the average age at death of females in Table B are misleading, especially with regard to the three classes of occupation with the lowest average age at death. There is no doubt that for these occupations the low figures are due to the fact that women do not follow these occupations all their lives, but sooner or later take up the occupations included in the other three classes, in which, in consequence, the average age at death is higher.

Sommerfeld [1] gives the results of a detailed study of the influence of occupations without and with the formation of dust. His calculations are based on the results obtained in thirty-eight Berlin hospitals. During the time over which the investigation extended there were 906,341 patients in these hospitals, of which number 9761 died. Of the deaths, 5449 resulted from diseases of the respiratory organs, of which number 4675 were due to tuberculosis.

If the occupations are divided into those without and those with dust, we find marked differences. In the first group the death-rate from tuberculosis is 2.39 per 1000; in the second group, 5.42 per 1000; of 1000 deaths, there were in the first group 381 from tuberculosis, in the second, 480. If these results are compared with the conditions among adult males in Berlin, over fifteen years of age, we find that the laborers in occupations in which there is formation of dust are affected not very much more unfavorably than the average, the laborers in the occupations without dust-formation far more favorably.

	Of 1000 living, there died of tuberculosis—	Of 1000 deaths, there were from tuberculosis—
Occupations without dust-formation	2.39	381.0
Occupations with dust-formation	5.42	480.0
Occupations with formation of—		
1. Metallic dust	5.84	470.58
a. Copper dust	5.31	520.5
b. Iron dust	5.55	403.7
c. Lead dust	7.79	501.0
2. Organic dust	5.64	537.04
3. Mineral dust	4.42	403.43
Average	5.16	478.9
Adult males of Berlin of same age, general population.	4.93	332.3

Among the occupations in which there is mineral dust, stone-cutters and workers in glass and porcelain are

[1] *Hygienische Rundschau*, Jahrg. vii., S. 44.

excluded. When we include these the table is changed in that the occupations with mineral dust assume the first place. Of 1358 stone-cutters, distributed among ten places, Sommerfeld found 61 deaths, indicating a death-rate of 39 per 1000; of 497 deaths, 444 were due to tuberculosis = 893.3 per 1000. Among workers in glass the death-rate from tuberculosis was 375 per 1000; among glass-grinders, 500 per 1000; and among workers in porcelain, 600 per 1000.

A great deal has been accomplished in recent years in preventing the detrimental influence of the different irritating and poisonous gases and fumes evolved in certain manufacturing processes. The employment of special ventilating flues and hoods to remove the poisonous gases obviates, to a large extent, the danger from such gases, and has rendered these occupations far more healthful.

In the mechanical trades, where irritating dusts are most frequently encountered, there has also been great improvement through the introduction of special appliances around each machine, whereby the dust is exhausted from the work-room at the point of production, though it is impossible to remove these dusts entirely. In the grinding of metals the formation of dust has been greatly diminished in many localities by the prohibition of dry grinding.

Moritz and Röpke[1] report upon a detailed study of the hygienic condition of the metal-grinders of Solingen, Germany. The death-rate among the grinders from 1885 to 1895 was 20.6 per cent., as compared with only 13.6 per cent. for the remainder of the population. Of 100 deaths in men over fourteen years of age during the same time, 72.5 per cent. of the deaths among the grinders were due to tuberculosis; among the remainder of the population, only 35.5 per cent. On examination of the grinders, only 16 per cent. were found to be healthy; 5.7 per cent. complained, but in these no disease

[1] *Zeitschrift f. Hygiene*, Bd. xxxi., S. 231.

was found; and 78.3 per cent. were diseased. Of those over forty-five years of age, none were found that were healthy.

Moritz and Röpke state that the dust produces an irritation of the mucous membrane of the nose, resulting in the formation of boils. There is also a cutaneous eruption and a swelling of the nose. Later, a certain degree of tolerance is established, but the mucous membrane of the nose becomes atrophic. This condition was found in 23.2 per cent. of the workmen, as compared with 12.2 per cent. in the remainder of the population. 32.2 per cent. suffered from chronic nasal catarrh, 48.2 per cent. from catarrh of the pharynx, and 12 per cent. had disease of the lungs. The feeling of dryness of the throat leads to the consumption of large amounts of fluid. The effects of the excessive use of alcoholic beverages was shown in 11 per cent. with fatty heart, and 5.4 per cent. with fatty liver. Rheumatic affections were found in 4.4 per cent.

The authors state that in order to prevent the formation of dust wet-grinding is to be recommended wherever possible. For the removal of dust from the point of production, ventilation apparatus of special construction must be used; but, since even with the most perfect dust-exhaustion apparatus the penetration of dust into the work-room is not entirely prevented, it is necessary to remove the dust deposited on the surfaces in the room as frequently as possible.

The grinders must exercise the greatest degree of cleanliness, not only of the work-room, but also of their persons, and the introduction of shower-baths into new establishments is desirable.

In order to protect the health of the grinders from the highly injurious effects of the dust, they should be required to breathe through the nose, and assume an upright position as much as possible.

The reduction of the number of working-hours is also recommended, and the observation of pauses about the

middle of the forenoon and afternoon to permit the workmen to spend a short time in an atmosphere free from dust. A ten-hour day for adults, and an eight-hour day for youths, are considered the maximum.

The following regulations were passed in 1883 concerning establishments in which metal goods are ground and polished: The work-rooms of all new establishments erected, or of extensions of old establishments, must have a height of at least 3.5 meters, the windows must have at least one-twelfth the floor surface, and each person must be supplied with 16 cubic meters of air space. The floors must be tight, and the walls must be freshly painted or whitewashed at least once a year. Clay floors in new establishments or extensions are prohibited.

Shuler has made a detailed study of the hygienic condition of the millers of Switzerland.[1] He studied the sick lists of hospitals, and gives an analysis of 108 cases. These were:

Diseases of the digestive organs	17
Diseases of the respiratory organs	34
Diseases of the circulatory organs	3
Tuberculosis	12
Rheumatism	19
Diseases of the eyes	4
Diseases of the skin	19

Under the diseases of the respiratory organs there were 8 cases of pneumonia and pleurisy, and under the diseases of the skin there were 6 cases of itch and pediculosis, and 3 of eczema.

Shuler states that if we take certain disease-groups into consideration, we find in 1000 workmen the number suffering from diseases of the respiratory organs distributed as follows: Millers, 42.3; cotton-spinners, 47.7; embroiderers, 70.7; and workmen in mechanical establishments, 76.8. The number suffering from diseases of the skin are distributed as follows: Millers, 10.2; cotton-spinners, 16.5; embroiderers, 24.2; and mechanics, 32.8.

[1] *Deutsche Vierteljahr. f. oeffentliche Gesundheitspflege*, Bd. xxix., S. 513.

The millers, who in 1888 numbered 5412, had, in the years 1883 and 1884, 1388 deaths, at the following ages:

Age.	Fifteen to nineteen.	Twenty to twenty-nine.	Thirty to thirty-nine.	Forty to forty-nine.	Fifty to fifty-nine.	Sixty to sixty-nine.	Seventy to seventy-nine.	Over eighty years.
Total	24	85	130	200	320	360	267	82
Tuberculosis .	6	29	46	59	63	26	8	0

Of the millers, 16 per cent. died of pulmonary tuberculosis, while in the same years for the total population of the cities of Switzerland, with over 10,000 inhabitants, only 14.4 per cent. died of the same disease. The death-rate from tuberculosis in the cities is 2.95 per 1000, while among millers it is 3.65 per 1000.

In the report of Dr. Kummer, formerly Chief of the Statistical Bureau, in Bertillon's *Encyclopedia of Hygiene*, on the death-rate from tuberculosis in Switzerland for the years 1879 to 1882, the rate is given for a number of different occupations. In 1895 Dr. Crevoisier reported on the same subject in the Swiss statistical Zeitschrift based on material of the statistical bureau for the years 1881 to 1890. These reports differ as to the general death-rate from tuberculosis, but coincide fairly well as to the death-rate from this disease for the different trades.

According to Kummer.		According to Crevoisier.	
Landlords	1.37	Landlords	1.80
Textile-workers	2.14	Cotton-weavers	2.15
Laborers (indoors)	2.58	Laborers (indoors)	3.10
Millers	2.70	Millers	3.50
Masons	2.74	Bakers	3.70
Shoemakers	2.90	Silk-weavers	3.70
Machinists	2.96	Masons	3.80
Butchers	3.14	Shoe-makers	4.00
Bakers	3.33	Machinists	4.20
Tailors	3.34	Dyers and Printers	4.70
Carpenters	3.40	Carpenters	4.70
Book-printers	3.65	Book-printers and Lithographers	6.60
Locksmiths	4.88	Locksmiths	7.01
Stone-cutters	6.87	Stone-cutters	8.00

The danger from accidents varies in the different trades and occupations. The Swiss Secretary of Labor states that among 1000 laborers accidents occur as follows:

Cotton-spinners	22.2	Brewers	66.7
Millers	28.0	Masons	80.5
Paper-manufacturing	31.1	Smiths	93.1
Carpenters	35.2	Metal-turners	102.1
Locksmiths	46.9	Moulders	132.4

The Effect of Anilin Dyes and Nitrobenzine and Its Compounds.—Dr. Walter Malden[1] investigated the poisonous action of these substances upon individuals whose occupation was concerned with constant handling of these substances, as well as the influence of these substances upon animals.

In anilin workers the following appear to be the most important points which are shown by a blood examination. (1) An increase in the number of red corpuscles when the amount of poison absorbed is small and constant. (2) A decrease in the specific gravity and hemoglobin of from 5 per cent. to 50 per cent. (3) A low color index, showing that renovation of the corpuscles is proceeding more rapidly than the manufacture of hemoglobin. (4) Degeneration or imperfect development of the red corpuscles as shown by the variations in size and the presence of corpuscles containing basophil granulations. (5) Abnormal leukocytic percentages, consisting principally in a diminution in the polymorphonuclears and an increase in the other cells, particularly the lymphocytes, eosinophils, and mast cells. The following appear to be the most important effects: (1) Dinitrobenzol is more toxic than anilin, and causes more cases of acute poisoning than any other of the nitrobenzine series. (2) It quickly affects the men who work in it, even within one week. (3) The occurrence of red corpuscles showing basophil granulations is the first recognizable sign in the blood of poisoning by this substance. (4) The number of red cor-

[1] *Jour. of Hyg.*, vol. vii., Oct., 1907, p. 672.

puscles is reduced after a short time by one to one and a half million per cubic millimeter. (5) The specific gravity and hemoglobin content are reduced in about the same ratio as the red corpuscles; therefore, the color index is not far removed from unity. (6) Some leukocytosis, principally lymphocytosis, occurs in some stage of chronic poisoning. (7) Even when there is considerable cyanosis, the presence of methemoglobin cannot be detected spectroscopically except in the more severe cases.

Malden showed by animal experiments that anilin, whether injected subcutaneously or inhaled as vapor, very rapidly produces its destructive action on the blood.

This action is manifested by the following points in chronological sequence: (1) Production of methemoglobin in the blood. (2) Hemolysis and destruction of red corpuscles. (3) Rapid fall in the specific gravity and hemoglobin content of the blood, accompanied by a slight reduction in the number of leukocytes. (4) A continued increase in the number of polymorphonuclears, with a corresponding increase in the lymphocytes. (5) The occurrence in the red corpuscles of basophil granules and polychromasia. (6) The occurrence of nucleated red cells in severe cases. (7) Recovery after severe poisoning is rapid and continuous, and apparently no permanent disability is entailed.

These animal experiments corroborate the findings in the blood of anilin and nitrobenzine workers and enable us to follow the sequence of events, which appear to be the same in cases of poisoning by either of these substances, though they are much more marked in the case of the latter. These substances may gain access to the body by—(1) inhalation of their vapors; (2) absorption through the skin; (3) absorption from the alimentary canal after being swallowed.

In the less severe cases of poisoning in which methemoglobin is not present in sufficient amount to be detected spectroscopically, the changes which may be found in the blood are sufficiently characteristic to enable

a diagnosis of anilin or nitrobenzine poisoning to be made. These consist in: (1) A decrease in the percentage of hemoglobin as estimated from the specific gravity of the blood of from 5 per cent. to 50 per cent. (2) A decrease in the number of red corpuscles, if the amount of poison absorbed is considerable; if the dose is very small, this decrease is not found, blood formation apparently keeping pace with blood destruction. (3) Degeneration and imperfect development of the red corpuscles, as shown by the occurrence of basophil granulations, polychromasia, poikilocytosis, and variations in size. (4) The presence of nucleated red corpuscles in severe cases. (5) A decrease in leukocytes, rapidly followed by an increase, the increase being principally due to the number of lymphocytes.

The simultaneous occurrence of all or several of these signs in the blood enables a diagnosis of poisoning by anilin or nitrobenzine to be made in quite mild cases. Cessation from work for a short time enables the blood to recover rapidly from the effects of poisoning.

Special Industrial Diseases.—The European War has brought into great prominence the dangers of a variety of industrial poisonings that are encountered in industrial establishments, especially in munition factories. These are more especially risks from exposure to lead, tetrachloride of ethane, nitrous fumes, and certain explosives which may cause fatal illness, or cause troublesome skin affections (dermatitis), as trinitrotoluol, tetryl, fulminate of mercury, and lubricating and cooling fluids used in metal turning.

Lead-poisoning occurs from coming in contact with lead and its compounds in a variety of processes in munition factories, in smelting lead and spelter, in making sheet lead and bullets, in file-cutting, in hardening and tempering metals, in tinning, in soldering and plumbing, in the manufacture of storage-batteries, in the manufacture and use of lead paints and red lead, and in the manufacture of rubber and rubber goods.

In some of these industries the lead gains access to the body principally by the inhalation of lead fumes and dust, in others the lead gains access to the body principally through the digestive tract by eating with unclean hands, or by putting pipes or other articles into the mouth while the hands are soiled. A daily dose of 2 mg. of lead is likely to produce chronic poisoning.

The inhalation of lead dust or fumes can be avoided by preventing dust formation and by assuring that the fumes are carried out of the place where the workmen perform their work. This is a most difficult problem, but the danger can be greatly diminished by localized exhaust ventilation. An additional precaution should be taken by enforcing the wearing of respirators by all the workmen that are exposed to lead dust or fumes.

The absorption of lead through the alimentary tract can be diminished by instructing the men concerning the danger of the ingestion of lead carried to the mouth on dirty hands. Under no circumstances should the workmen be allowed to eat a meal in the workroom, nor without removing soiled outer garments, nor without carefully washing their hands. Special washing facilities should be supplied and smoking should be prohibited in the workrooms.

Trinitrotoluol is absorbed in the form of dust and fumes and is a substance of increasing importance because of the large quantities used in munition factories. Every effort should be made to prevent dust formation and the escape of the dust into workrooms. The fumes should be carried off by local exhaust ventilation. The skin of the workers should be protected by wearing overalls and leather gloves. Especial care is required to prevent carrying the poison to the mouth by dirty hands.

Tetryl (tetranitromethyl-anilin) is a highly poisonous explosive dust which may give rise to eczema. This effect can be prevented by avoiding the escape of dust

into the workroom. The wearing of light gauze veils by the workers is also some protection against this poison. Adequate facilities for washing should be provided.

Tetrachlorathane is a non-inflammable liquid used to dissolve acetate of cellulose, and is used to varnish the wings and other parts of aëroplanes to make them impervious. The liquid volatilizes and the vapor smells like chloroform and is a powerful anesthetic. It is twice as heavy as air and tends to sink to the floor. The inhalation of the vapor produces drowsiness, loss of appetite, constipation, and pains in the stomach. In serious cases jaundice, destruction of the liver cells, coma, and death are the effects produced.

The exposure to the vapor should be reduced to a minimum. Local exhaust ventilation is imperative and no other work should be carried on in the same room. Special attention should be given to the ventilation of the workroom.

Nitrous fumes are encountered in munition factories. The effects of these fumes are seen in irritating cough, congestion of the bronchioles, dyspnea, and collapse.

Workmen should be warned against the danger of inhaling nitrous fumes, and appliances should be installed to conduct the fumes away from the workmen. Ample ventilation will aid in reducing the danger to the workmen from this form of poisoning. The fumes are insidious in their action and consequently may not be noticed until a fatal dose has been inspired unless the workmen are properly warned beforehand.

Influence of the Length of the Working-day on the Health of the Laborers.—Dr. E. Roth,[1] in a paper on this subject, makes the following statements:

[1] *Deutsche Vierteljahr. f. oeffentliche Gesundheitspflege*, Bd. xxvii., S. 277.

"1. The length of the working-day must be shorter the greater the amount of mental or physical energy required, or the greater the danger from the industrial occupation.

"2. The length of the working-period must be shorter the less developed and the less resistant the organism of the laborer.

"3. Women and youths must be excluded from all work in which great physical energy is required; also from industries in which their health may be affected by the action of poisonous substances or dust, or which require special and continued attention.

"4. Laborers of eighteen years of age are to be included in the protected class of fourteen to sixteen years of age.

"5. Even where the factory-work does not exert a direct effect upon the mental or physical condition, and is not accompanied with particular danger from accident, the length of day must not exceed a definite number of hours.

"If a universal maximum is to be established, then a ten-hour working-day may be established in general when the existing conditions are favorable, and a longer working-period may not be allowed either in the interest of the laborers or their employers. Exception must be made in those occupations in which no definite working-day can be established.

The following tables do not indicate any marked decrease in the number of sick-days per laborer after a reduction in the length of the working-day from nine to eight hours:

Male Laborers.

YEAR.	Length of working-day.	Average number working.	Number of working-days.	Number of sick-days.	Per cent. of working-days.	Sick-days per laborer.	
1889	9 hours.	114	35,568	726	2.04	6.37	
1890	9 "	141	43,992	808	1.84	5.73	
1891	9 "	116	36,192	478	1.32	4.1	
1892	8 "	97	30,264	256	0.84	2.64	8 hours after April 1.
1893	8 "	105	32,760	660	2.01	6.2	

Female Laborers.

YEAR.	Length of working-day.	Average number working.	Number of working-days.	Number of sick-days.	Per cent. of working-days.	Sick-days per laborer.	
1889	9 hours.	225	70,200	1286	1.83	5.71	
1890	9 "	236	73,632	1942	2.63	8.2	
1891	9 "	247	77,064	1007	1.30	4.08	
1892	8 "	230	71,760	1205	1.61	5.2	8 hours after April 1.
1893	8 "	204	63,684	1404	2.20	6.9	

"6. The system of working overtime should be earnestly discouraged.

"7. For youthful workers a forenoon and an afternoon pause are necessary aside from the midday intermission.

"For adult laborers these special pauses are required when the midday pause is only one hour, and when the working period of the forenoon and afternoon exceeds four hours, or the total working-day exceeds eight hours."

Lighting of Industrial Establishments.—The hygienic requirements in the artificial lighting of industrial establishments are given very succinctly by Erismann, in a paper on "Artificial Lighting, with Special Reference to Distribution of Light,"[1] in which he states that: "Hygiene makes the following demands on the lighting technic:

"1. The quantity of light falling upon each work-place—the so-called degree of light—as well as the brightness of the surface, must be sufficiently great. For coarser work on good reflecting surfaces 10 meter-candles are sufficient; for finer work and with unfavorable reflection conditions, on the other hand, at least 25 to 30 meter-candles are required. The quantity of light is to be measured photometrically.

"2. The pollution of the air by the products of com-plete or incomplete combustion of the illuminating-aterial shall be as low as possible. The purity of the iminating-material must be insisted upon. And since th the increased amount consumed the absolute quan-y of the combustion-point is increased, under like

[1] *Deutsche Vierteljahr. f. oeffentliche Gesundheitspflege*, Bd. xxii., S. 11.

conditions that form of illumination is to be desired in which the total consumption of illuminating-material per degree of light is lowest.

"3. Artificial lighting must not produce any perceptible increase in the temperature of the illuminated room; therefore the heating effect of the source of light must be as low as possible. In systems of illumination in which large quantities of hot combustible gases are produced, these must be efficiently removed. To lessen the heat-production through hot gases, it is important that as large an amount as possible of the energy produced is converted into light, and in consequence that the consumption of illuminating-material in proportion to the brightness of the flame is as low as possible.

"4. The heat-rays of the source of light must not produce any discomfort. The discomfort can be diminished by increasing the distance between the heated body and the persons in the room. Since, however, the amount of light is rapidly diminished by this means, the conditions for diminishing the discomfort from heat-rays must be sought in the system of illumination itself; therefore such sources of light are to be selected in which the caloric equivalent of the non-luminous portion of the flame is as low as possible. The construction of the burners or the lighting apparatus must be of such a nature that the lowest possible radiating effect is obtained. As the best source of light, other conditions being the same, must be considered that in which the heat-radiation per candle-power of light is the lowest. The heat-radiation of an ideal source of light should be extremely small. From this standpoint the color of the light is not without significance, since a light which possesses many red rays indicates, in general, a high, and a light with principally green and blue, on the other hand, a low heat-radiation.

"5. Sources of light that possess a high reflecting power, in which a large amount of light falls upon a unit of surface, must be shaded from the eyes or weakened in some way.

"6. Flickering of the light and decrease in the intensity of the light are to be avoided in the illumination of rooms. A uniform, steady light is everywhere to be desired, and is absolutely necessary where work is carried on in which the eyes are used for a long time, or to a large extent (school-rooms, certain factories, etc.).

"7. The dangers—poisoning, explosion, fire, electric shock—to which the consumer or the public is exposed in general through installation or conduction of illuminating-arrangements, shall be as small as possible.

"8. Of not less importance, and for certain rooms (school) of more importance than the supplying of as large a quantity of light as possible, are the uniform distribution of the light and the reduction of shadow-production. This requirement can be fulfilled in direct illumination only under especial circumstances. The end is most simply and surely attained by the use of indirect (electric) light. For school-rooms this is the only mode of illumination which meets all the hygienic requirements. It can also yield very good results in factories. The discomfort from heat-radiation is entirely removed, because the source of light is raised high above the heads of the occupants.

"A combination of direct light with indirect, by means of white-glass reflectors, is not to be recommended where there is shadow-formation (as in writing), and metal reflectors are to be preferred."

CHAPTER XII.

SCHOOL HYGIENE.

A LARGE proportion of the ill health of a community is found in children of school age, and since such a high percentage of this ill health can be prevented, it is necessary to treat briefly the subject of school hygiene.

Site, or Location, with Reference to Drainage Capacity of the Soil.—In school architecture a question of primary importance, the consideration of which is frequently neglected, is that of location with regard to the nature of the soil and its drainage capacity. Satisfactory sanitary arrangements can rarely be secured in any building unless the site of the building is carefully selected with regard to the drainage capacity of the soil. The soil structure as regards the preponderance of definite-sized grains, coarse or fine, influences the drainage capacity, and consequently the healthfulness of the site. The amount of slope and the proximity of streams, either surface or underground, also influence the character of the soil. For these reasons it is of primary importance that the site selected for a school-building shall be of such a nature as to afford the very best facilities for drainage, not only for refuse and excreta collected in the building, but for surface- and rain-water flowing over the soil. Whenever the soil of the site is not perfectly dry, it should first be underdrained.

Parkes states that the conditions which insure healthy habitations are:

1. A site that is dry and not malarious, and an aspect which gives light and cheerfulness.

2. A pure supply and proper removal of water, by

means of which perfect cleanliness of all parts of the house can be secured.

3. A system of immediate and perfect sewage removal, which renders it impossible that the air or water shall be contaminated from excreta.

4. A system of ventilation which carries off all respiratory impurities.

5. A condition of house construction which insures perfect dryness of the foundation, walls, and roof.

Structure of Walls.—Having selected a proper site for the building, the nature of the building is of considerable importance. The building itself should be detached, so as to obtain an abundant supply of fresh air and the greatest amount of light. The character of the materials composing the walls and the thickness of the walls, the number of layers composing them, all have an important influence on the character of the building. The walls should be rendered impervious to moisture, and it is preferable, therefore, to have double walls with an air space between the inner and outer surface. The materials employed in constructing the walls will be governed by circumstances, and their nature is not of great importance if they are properly used. Stone walls are usually somewhat damp, but can be rendered perfectly dry by allowing an air space between the inner and outer layers.

Cubic Space and Floor Space.—**Cubic Space.**—From calculations made by Prof. Parkes and Dr. de Chaumont, the amount of air required for each adult per hour, in order to maintain a certain degree of purity in the atmosphere, is 85 cubic meters. The respiratory impurity added to the air will, of course, be less with children than adults, consequently the amount of air required to maintain the standard of purity will be less. Though children evolve less carbon dioxid in a given time than adults, yet relatively for their body-weight they expire more. In fixing a standard for schools, the age of the children ought also to be considered; the average amount of air re-

quired being about 55 cubic meters per hour. Parkes says that it is highly desirable that some general agreement should be arrived at as to the amount of air necessary, even if it be admitted that the desired amount cannot always be obtained. If we adopt the following amounts of carbon dioxid as being evolved during an hour in repose, we shall not be far from the probable truth:

Adult males .	(say 70 kilograms weight),	0.72 cubic foot	= 20	liters.
Adult females	(" 51 " "),	0.6 "	= 17	"
Children . . .	(" 35 " "),	0.4 "	= 11.25	"
Average of a mixed assembly		0.6 "	= 17	"

The amount of fresh air that must be supplied in order to prevent the impurity due to products of respiration exceeding a particular limit, is measured by the quantity of carbon dioxid present in excess over that in external air, according to either of the standards in use, and may be calculated from the formula $\frac{e}{r} = d$, where e = amount of carbon dioxid expired in liters per head per hour; r = admissible limit of carbon dioxid due to respiratory impurity, stated per liter; d = delivery of fresh air per head in cubic meters.

Under these conditions the amount of fresh air to be supplied in health during repose ought to be:

For adult males	3600 cubic feet per head per hour	= 102	cubic meters.
For adult females	3000 " " "	= 85	" "
For children . .	2000 " " "	= 57	" "
For a mixed assembly . .	3000 " " "	= 85	" "

The law of Massachusetts requires that each occupant of a school-room receive a quota of 850 liters of air per minute. If this is taken as the basis for the minimum amount of air required by each child, and we require further that the air be changed but three times each hour, then the minimum amount of cubic space allowable for each child is 17 cubic meters. This is slightly lower than the theoretical amount, as shown by the calculations of Parkes,

but it is far in excess of the amount of space usually supplied in common schools.

When the air of a room is changed more frequently than three times an hour, there is always more or less draft in some portions of the room, and for this reason the minimum amount of space allowed should be 17 cubic meters. Even with this amount of cubic space it is impossible to keep the air of rooms of the same purity as outside air, owing to the gases given off during respiration. For this reason a certain amount of respiratory impurity, as it is called, is permissible in well-ventilated rooms. With the outside air containing 0.4 part in 1000 of carbon dioxid, the additional amount permissible as coming from respiration is 0.2 part in 1000, making a total amount of carbon dioxid in the air of 0.6 part in 1000. It should be our aim in the ventilation of school-rooms to maintain the respiratory impurity at this low standard, and this it is possible to do if the initial cubic space is sufficient—say 17 cubic meters—and we have reliable mechanical means for introducing the requisite amount of fresh air each hour. If the cubic space is less, or the arrangements for the introduction of fresh air are imperfect, it is impossible to have perfect ventilation and pure air. It is, therefore, merely a matter of choice on our part whether we will elect to have efficient ventilation or not. It can be obtained by making the necessary expenditure. Without this it is impossible to obtain it.

Floor Space.—Each child should have a floor space of at least 4.25 square meters. This amount of floor space, when the height of the room is 4 meters, will give each child a minimum cubic space of 17 cubic meters. The amount of floor space is an important factor, inasmuch as it is brought into relation with the height of the room.

Relation of Window Space to Cubic Space.—In fixing the height of stories, when not governed by the amount to be expended, the height of the basement should be 2.8 to 3 meters. The first story should be

3.9 and the second story 3.8 meters in height. Light in rooms of the second story is always superior to that of the first, consequently the increased height of the first story. There is also usually an increase of glass surface provided for the first story to equalize the difference in light. The window heads should be finished to the top, so that no shadow can be thrown on the ceiling. The sills of windows should be 1 meter from the floor. The proportion of light to floor of class-rooms should never be less than 1 square meter of glass surface to 6 square meters of floor surface, for rooms 10 meters wide, lighted from only one side. Within the limits of a city, where the adjoining buildings are about 6 meters from the exterior walls, this proportion should be increased to 1 to 5. The length of the school-room should not be over 15 meters, and the width not over 10 meters, while the height should be at least 3.8 meters.

Lighting.—The lighting of school-buildings is a matter of very great importance. The windows should never be in the front of the room, only at the sides and rear. It is preferable to have them on the left side of the room, so as to have the light falling over the left shoulder of the pupil. The windows should be provided with shades or blinds, so that direct sunlight can be excluded as required.

As the sense of sight is the chief medium of education, it is hardly possible to overestimate the importance and necessity for carefully observing the management of light in school-rooms. It has been positively established by careful and extensive statistics that myopia is most frequently, if not exclusively, developed during school-life. This is due partly to the fact that the eye during this period of growth is more liable to change in form, and partly to the fact that children have much stronger power of accommodation than adults, and therefore hold objects more closely to the eye. The book or paper should never be closer to the eye than 25 centimeters. If there is myopia sufficient to prevent the letters from

being distinct at this distance, it is better to wear glasses in the study-room. In erecting public schools it involves a little extra expense to provide windows of sufficient size. Architectural beauty ought to be a secondary consideration where such grave practical interests are involved. Dr. Cohn maintains that a school-room cannot have too much light, and recommends the very large proportion of 1 square meter of window glass for every square meter of floor surface, and that less than about one-half of this proportion should never in any case be allowed. The arrangement that Mr. Eiberich advocates is to have the class-rooms of oblong shape, the windows being on one of the long sides and the desks arranged parallel to the short walls, so that the light falls from the left side.

The Position of Blackboards.— The blackboards should be on the inner wall of the room, where the greatest amount of light will fall upon them, and they should be of a dull-black color. The principal cause of defective eyesight in school-children is no doubt traceable to improper lighting of the room, which may be either excessive light or deficient light, or light coming from the wrong direction. The position of the blackboards and their frequent use for copying exercises, while the child is at its desk, require rapid changes in the accommodation, which is also a factor in producing defective eyesight. Another factor, independent of the arrangement of the school-room, is the use of books printed with defective type or with too small a type.

Corridors, Cloak-rooms, and Wardrobes.—The corridors should be without obstruction, and never less than 2.4 meters, preferably 3 meters, wide. The stairways should be 1.8 meters wide, and each flight should be broken with a landing. These stairs should be as near to the exit as possible, and equally placed at each end of the building. The walls should be of brick, and finished in white enamelled brick or white enamelled paint. Wall-paper should never be allowed in school-rooms, because

of the difficulty of maintaining it in a proper sanitary condition.

As contagion is most likely to occur from garments, which, if porous, absorb and transport gases, bacteria, etc., it is necessary to have two wardrobes properly arranged on each floor, one for each sex. The latest improved wardrobes, set up in separate rooms or in the corridors, either in the basement or on each story, are made with separate stalls of channel iron. At the bottom is a shelf for rubbers, two rings and cups for umbrellas, with hangings on each side. The best place for wardrobes is in each corridor, provided it is wide enough. Wardrobes seem to be the most difficult problem of school sanitation, there being many advantages in the method of placing them in wide corridors, unless special rooms can be provided, with thorough circulation of fresh air. The advantage of having wardrobes in the corridors is that the teacher in charge of that floor maintains the discipline, and there will be no travelling up and down to the basement.

Ventilation.—With regard to the introduction of fresh air, probably the most satisfactory arrangement for a school-building is that by means of indirect heating, where the air required for ventilation is brought in at the desired temperature, thus maintaining the temperature of the room, while the purity of the atmosphere is secured at the same time.

As to the best method to introduce the requisite amount of air into school-buildings, numerous systems of ventilation and heating are in use, several of which give satisfactory results, if properly constructed. If the building contains as many as eight or ten rooms, and is two or three stories in height, it is impossible to ventilate it satisfactorily without the introduction of fans to assist in either propelling the incoming air or extracting the foul air of the rooms. It is customary to have one of these blowers in the shaft through which fresh air, already heated by passing over steam coils, makes its entrance

into the room to be warmed and ventilated. These shafts are usually supplied with a by-pass valve, which is under the control of a thermo-regulator, so that the supply of air is kept at a definite temperature automatically. As soon as the temperature rises above the desired point, the thermo-regulator cuts off the supply of heated air, and allows cold air to enter and mix with the heated air. This not only facilitates the proper ventilation of the rooms, but likewise economizes the amount of fuel used. By means of fans it is possible to introduce a definite amount of air in a definite period of time, the entire circulation of air being under control.

In this method of ventilation and heating it is possible to place the intake of fresh air at such a point as to prevent some of the grosser atmospheric impurities from gaining access to the building. This point of intake may vary according to the location of the building; ordinarily, it should be at least 2 or 3 meters above ground. It may be over the roof of the house, if it is found that at that point the air is purer than at a lower level. It is also possible by this method of ventilation and heating to filter the air, in order to remove the grosser dust particles, by passing it through a screen over which a constant stream of water is flowing. It is also possible to regulate the humidity of the air, to some extent, through this method of filtration, the air taking up some moisture in passing over the screen.

Heating.—Heating may be accomplished either by what is known as direct heating, as by use of a stove or open fireplace, or through steam or hot-water radiators in the room. Or it may be by what is known as indirect heating, where the radiating surface is in some other portion of the building, and the rooms are heated by bringing in air that is warmed by passing over steam or hot-water coils. Where a system of direct heating is employed, whether with steam or hot water, the capacity of the heating plant should be adapted to meet the requirements placed upon it. Mr. William J. Bald-

win, in his *Steam Heating Data*, states that the question of condensation of steam receives the first consideration in making calculations for the heating of a building. If asked the question why condensation is considered first, he would reply that "it furnishes us with the first item of data on which to base our calculations. For instance, when we find the amount of cooling or condensation that is to take place within a building in the coldest weather, we then know the amount of water it is necessary to evaporate to do this work. Having the amount of water evaporated, we can then obtain, in the order we please, the size of boiler necessary to evaporate the water, the amount of coal or other fuel that will evaporate that amount of water, the size of the grate on which to burn the coal, the size and height of chimney necessary to supply air for combustion, the size of the radiators necessary to condense the steam, the size of pipes necessary to convey steam or hot water to the radiators, and all other attendant data which will develop as we proceed."

Water-supply and Sewage Disposal.—The building should have an abundant supply of pure water, so as to insure against the diseases ordinarily carried by water; also to facilitate the maintaining of strict cleanliness among the children in the building. The children should be provided with individual drinking-cups or paper cups should be supplied free of charge. In this way the possibility of the more or less direct transmission of disease-producing bacteria is reduced. Drinking-fountains also serve to limit the dissemination of the infectious diseases. It is also necessary to devise some method for the disposal of the sewage, in the absence of a system of sewers. This becomes a separate question in different localities. In some instances, where the price of land permits, it will probably be safest and cheapest in the end to have some form of surface irrigation. Where the price of land does not permit this method of disposal, it may be necessary to resort to properly constructed cesspools or some of the modern methods of purification.

Water-closets and Latrines.—Where there are no sewers we unhesitatingly use the closets; but these should discharge into specially constructed tanks or cesspools, so that the sewage may be disposed of in a sanitary manner. There should be no connection of any kind between the class-rooms and the water-closets. In no case should wastes of sinks be discharged into the vaults. The wastes should enter a cesspool, preferably a double cesspool —with a tight compartment for solids and a leeching one for liquids. The best urinal is of slate. Water-closets for the pupils' use, where there is water carriage, should be with automatic seats. The plumbing of the building should be the best obtainable, with tight joints and as few bends in the pipes as possible; and these pipes should be properly ventilated by means of an open trap outside the building, between it and the sewer, and by carrying the other end of the soil pipe up over the roof of the building, of the same diameter throughout. All the traps of the water-closets and sinks must be back-aired, in order to insure against the production of foul odors in the unventilated ends of the pipe; and also to prevent the unsealing of these traps.

Each story of the school-building should be provided with suitable water-closets, with automatic flushing arrangements. These toilet-rooms should also be provided with sinks, so as to facilitate maintaining a proper degree of cleanliness of the hands and persons of the pupils. The expense of soap and towels to the community is a small one compared with the detriment occasioned by permitting the children to come in contact with each other when some of them are not as cleanly as they should be.

Desks and Seats.—The height of the seat must correspond with the length of the pupil's legs below the knees. The seat may be horizontal or slightly curved. The back of the seat should be composed of an upper concave portion and of a lower convex portion, so as to conform to the back of the pupil, and it should be of suffi-

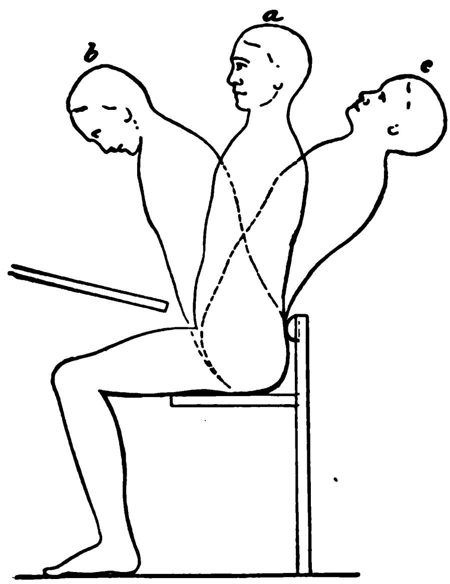


FIG. 52.—Comparative diagram showing (*a*) the proper position at a desk; (*b*) the position when the desk is too low; and (*c*) the position when the desk is too high (after Cohn).

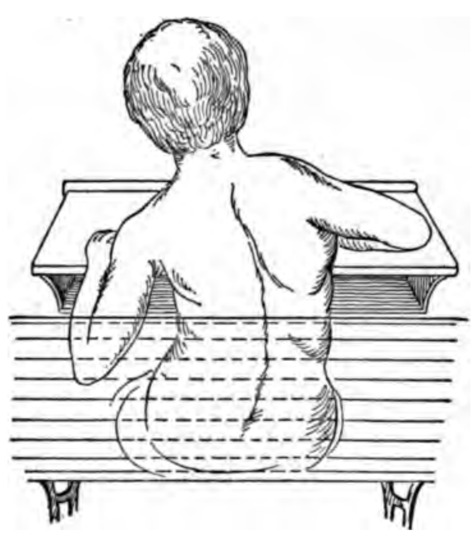


FIG. 53.—Position assumed in writing with the desk too high.

cient height to support properly the pupil's back. The writing desk should have an inclination of about 15 degrees. The desk should be fitted to the size of each pupil. The prevalence of lateral curvature of the spine in children is traceable to the use of desks that are entirely too high or too low (Figs. 53 and 54).

Defects in School Buildings.—In his annual report for the year 1917–1918[1] the Chief of the Division of Medical Inspection of Public Schools of Philadelphia states that, "Computation of the sanitary grade of the

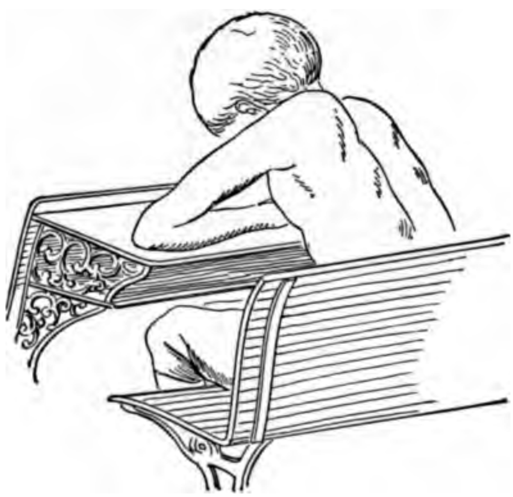


FIG. 54.—Position assumed in writing with the desk too low.

Philadelphia School plant, taken as a whole, and using the system devised by this division, was 84.8 of a possible perfect 100. The new school buildings are models of their kind, and some of the school districts, notably the 9th, present almost perfect conditions. The old school plant of Philadelphia, however, representing, as it does, the architecture of forty years ago, is badly in need of renovation. The 7th school district, representing an old portion of the city, furnishes the most marked example of this condition."

[1] *Annual Report of the Bureau of Health*, 1918, p. 216.

It is a well-known fact that the constant breathing of air markedly vitiated by the excretions from the lungs of other persons exerts a detrimental influence upon the vital powers of the system. Nevertheless we find many of our public-school buildings overcrowded, and in consequence the way is opened for the more general distribution of the micro-organisms of disease when brought into such an overcrowded space.

The greater prevalence of such diseases as diphtheria, measles, and scarlatina during the autumn months can be definitely traced to the very intimate association of children in overcrowded and poorly ventilated schoolrooms, and to the diminished resistance of their bodies to infection in consequence of the injurious effects of such overcrowding.

We have a general knowledge of the overcrowded condition of the public schools in different places, but, so far as I know, no systematic effort has been made to gather detailed information regarding the ventilation of the public schools, except that published by the State Board of Health of Ohio (1901) for all the schools in cities and towns of that State. This report is most interesting and important, and should be duplicated elsewhere. The tables given in this report show the number of square feet of floor space and the air space for each pupil in a room, as well as the ratio of window area to floor space. The investigation shows that 18 per cent. of the schools contain one or more rooms that fall below the minimum standard of 15 square feet of floor space, and a still greater number (28 per cent.) fall below the minimum standard of 200 cubic feet of air space, while 75 per cent. of the school-buildings have rooms that are deficient in light in that they fall below the standard of a window area of 20 per cent. of that of the floor space.

Conditions such as these are, no doubt, very general throughout the country, since there is no probability that the conditions are worse in Ohio than elsewhere. With conditions such as these prevailing in our public schools

it is no wonder that diseases of the respiratory tract are so readily disseminated among school-children. Moreover, deficient ventilation and lighting are potent agencies in undermining the vitality of the bodies of growing children. It is of the greatest importance that the children of our public schools be protected from all detrimental agencies possible.

Medical Inspection of Schools.—Medical inspection of schools and school children is conducted on one of two principal plans. In many European states the inspection is far-reaching in its effects, as the general health and development of the child are considered. Any defects in the physical condition of the children or their home and school surroundings are investigated and remedied. The other plan of school inspection is directed primarily toward the detection of infectious diseases among the children and the exclusion of sick children from school until they are well.

In some of the countries of Europe medical inspection of schools has been developed to a high plane. The position of school physician is an established one, and the duties of this officer are well defined. It is the duty of the school physician to examine and study the school buildings from a sanitary standpoint, as well as their contents and surroundings. It is his duty to investigate the purity of the air in each class-room, and analyze it systematically from time to time. He must inspect the lighting, heating, and ventilation of each of the class-rooms, and regulate the number of children in each room. On the basis of yearly measurement and examination of the children, he must direct the proper seating of each, not only with regard to the adaptability of the form and size of the desks to the age of the pupils, but also with regard to special requirements of certain pupils on account of defective eyesight or hearing. He is also required to analyze the drinking-water used in the schools, and endeavor to procure healthy drinking-water. When disinfection of the school becomes necessary, he must see that it is properly carried out.

When the school physician, in any of these instances, notices hygienic defects, he must inform the director of the institution, and make suggestions for remedying or removing such defects. He must also see that the laws of public health and the legislation of the board are carefully carried out.

With regard to the health of the pupils, it is the duty of the school physician to examine all new pupils on entering a school. These examinations are to be of such a detailed and systematic character as to afford a knowledge of the health of each child. He must make special observations to determine the extent to which the pupil may safely take part in the regular gymnastic exercises of the school, or whether these must be in part or entirely prohibited. He must examine each new pupil to determine whether it is suffering from any infectious disease, especially tuberculosis. He must also examine the spinal column to determine the presence of curvature, in order that special gymnastic exercises may be prescribed to overcome this defect. He must examine the eyes and ears, and determine the degree of vision and the hearing power.

These systematic examinations of the pupils are repeated during the school year, and a careful record must be kept of the progress of each pupil in regard to the uniform and healthful development of the body. These records should be commenced with the entrance of the child into the first grade of the schools, and the record should be carried up through the grades as the child is transferred from the lower to the higher grades.

The sanitary inspection of schools and school-children has been very generally adopted in the larger cities of the United States during the last decade. Where such a system is adopted, as in New York, Boston, Chicago, and Philadelphia, a corps of medical inspectors is appointed, whose duty it is to examine all children whom the teacher believes to be suffering from disease. In this manner many incipient cases of infectious disease are

detected and isolated before the danger of dissemination is very great. The great value of these inspections is shown in a report made by Dr. Cornell in his annual report of the work of the Division of School Inspection, Philadelphia (Report of the Bureau of Health, 1918). It gives the following summary of the physical defects encountered in the schools during the year ending June 30, 1918:

Eye	19,807
Nose, throat, and mouth	23,690
Ear	1,440
Teeth	71,695
Orthopedic	2,293
Nutrition	2,551
Heart	867
Nervous system	375
Defective mentality	183
Gastro-intestinal	20
Skin	15,817
Acute illness and accidents	2,542
Not vaccinated	1,131
Miscellaneous	761
Total	143,172

When a case of scarlet fever or diphtheria is found in the Philadelphia schools the class in which it occurred is dismissed for the rest of the day and the classroom is scrubbed with soap and water and thoroughly aired. The use of disinfectants in cases of school contagion has been abandoned. The abandonment of disinfection does not seem to have had any deleterious effect upon the incidence of contagious diseases; 176 school rooms were treated in this way during the year 1917–18. The diseases which called for the cleaning of the school rooms were as follows:

Diphtheria	53
Scarlet fever	118
Suspicious scarlet fever and diphtheria	3
Cerebrospinal meningitis	2
Total	176

During the year 1917–18 children were excluded from school for the following causes:

A. *Minor Contagious Diseases*

Acute conjunctivitis	515
Favus	9
Pediculosis	735
Acute sore throat	1113
Tinea circinata	75
Tinea tonsurans	42
Gonorrheal vaginitis	5
Dermatitis venenata	6
Total	2500

B. *Other Causes*

Not vaccinated	152
Observation cases (excluded three days)	603
Unclean and offensive	209
Acute illness	532
Total	1496

During the school year 1918–19[1] the following contagious diseases were discovered by school medical inspectors, school nurses, and the teachers:

	Found in classroom inspection.	Found waiting in school office.	Sent to office by teachers.	Found on home visits.	Total.
Scarlet fever	26	10	6	23	65
Diphtheria	3	2	2	..	7
Chicken-pox	24	13	17	13	67
Mumps	2	1	9	10	22
Whooping-cough	1	..	..	..	1
German measles	5	..	..	..	5
Scabies	21	8	41	2	72
Impetigo	42	7	72	2	123
Measles	..	..	..	8	8
					370

In addition to the medical inspectors, a number of trained nurses are also employed in the school inspection

[1] *Monthly Bulletin Dept. of Pub. Health of Phila.*, March, 1920, p. 38.

work. The nurses visit the homes of school children where their instruction may prove helpful, and in addition to this they treat cases of minor contagious diseases found by them in the schools or sent to them by the school inspector.

The medical department of the Philadelphia High School for girls was established in 1893. Prior to this time the attendance of any physician was depended upon in an emergency, so that much time was lost, and the uncertainty of obtaining assistance was great. In 1893 the services of a graduate of the Woman's Medical College were secured. The duties of the head of the medical department constantly increased from one hour a day to continual attendance from the opening of the school at 9 A. M. until the close of the session at 2 P. M.

At the beginning of each school year in September all vaccination certificates and scars are examined; in doubtful cases a certified re-vaccination is required. Teachers at the beginning of each morning session inquire whether any student is suffering from sore throat, headache or other ailment; all such are at once referred to the medical room. A daily record of students sent to the medical room is carefully kept. Any student with a temperature of 100° F. is detained in the "sick-room" until the temperature becomes normal. If a rise takes place, the student is sent home in a carriage. On stormy days students who have wet shoes, stockings, or skirts are required to report at the medical room, where dry garments are provided. All wet clothing is dried in a room prepared for the purpose, and is made ready for the student at recess in the medical room at noon. Every part of the entire building is thoroughly cleansed daily. The balustrades and desks throughout are carefully cleansed each day with antiseptic solution. The drinking-water is filtered, then sterilized, and the ice is made from sterile water. The sanitary condition of the toilet-rooms is excellent. There are now individual compartments, where formerly there were congregate rooms.

The objects to be attained in the systematic daily medical inspection of schools are: (1) The early detection of any cases of communicable diseases among the children and their prompt exclusion from the school. (2) The discovery of children suffering from non-communicable diseases or physical defects which hinder their proper advancement in their studies, such as defective vision and hearing. (3) To note the growth and development of the school-children. Defects in development and imperfect growth should be noted and the causes underlying them ascertained. In this respect the intelligent teacher can be of great assistance to the medical inspector in pointing out the defects noted through the more intimate association with the children. Where imperfect development arises from lack of proper or sufficient food and clothing, the social and financial condition of the parents should be brought to the attention of charitable organizations for investigation and amelioration.

Control of Disease in New York Schools.—"The modern conception of the transmission of infectious diseases has led to certain modifications in the attitude of the Department of Health in regard to its methods of dealing with these diseases in reference to the school.

"Cases of scarlet fever are excluded from school for at least five weeks, or until desquamation is complete and all purulent discharges have ceased. If quarantine is observed by the family, children and others who have had scarlet fever are immediately removed to another address. They may return to school at the end of five days, if, in the meantime, they do not develop the disease, but they must present a special school certificate issued by the department. If they continue to reside at home, they cannot return to school until the case of scarlet fever has been officially discharged by the Department of Health.

"In cases of measles, the patient is excluded from school until five days after the appearance of the rash, at which time, if he is otherwise well and all catarrhal discharges have ceased and the cough has disappeared, he

may return. Children, and other members of the family who have had the disease, may continue in school, provided that quarantine at home is properly observed. Children, or other members of the family who have not had the disease, and are immediately removed to another residence, may return to school at the end of fourteen days, the usual limit of the period of incubation, upon presentation of a special school certificate issued by the Department of Health; if continuing to reside at home, they must not be re-admitted until the case has been officially discharged by the Department of Health.

"Children suffering from German measles are excluded for one week, at the end of which time they must be seen by a school medical inspector and will be re-admitted on his certificate. Other members of the family who have not had the disease are excluded until the school medical inspector recommends their re-admission. Children in the family who have had the disease may remain in school.

"Children suffering from chicken-pox are excluded from school until all scabs have disappeared, at which time the child must be seen by a school medical inspector and re-admitted on his certificate. All other children of the family who have not had the disease are excluded until the school medical inspector recommends their re-admission. Children in the family who have had the disease may remain in school.

"Children suffering from whooping-cough are excluded from school until the whoop has entirely disappeared, which, generally speaking, means from six weeks to two months. In public, parochial, and all other free schools, a child must be seen by the school medical inspector and be re-admitted upon his certificate. In private schools, the child may be re-admitted on the certificate of his own physician. In either case the child must be again excluded if the characteristic whoop should recur.

"Children suffering from mumps are excluded until the swelling has entirely subsided. In public, parochial,

and other free schools the child must be seen by the school medical inspector and be re-admitted upon his certificate. In private schools, the child may be re-admitted on the certificate of its own physician. All children of the family who have not had the disease are excluded until the school medical inspector recommends re-admission. Children in the family who have had the disease may remain in school.

"Children suffering from diphtheria are excluded for a minimum period of twelve days, and must not be re-admitted until all symptoms have disappeared and the throat culture is negative on two successive days. A certificate from the Department of Health must be presented upon re-admittance. If quarantine is observed, children and others who have been immunized against the disease and cultures from whose throats do not show diphtheria bacilli may return to school. If children or others in the family are immediately removed to another address and cultures taken from nose and throat are negative, they may be readmitted, but must present a special school certificate issued by the department. If continuing to reside at home and the above precautions are not taken, they cannot be re-admitted until the case has been officially discharged by the Department of Health.

"When a teacher is a member of a family or household in which a contagious disease occurs the teacher must be excluded, except that continuance at school may be permitted at the discretion of the department. A special certificate must be issued for this purpose."[1]

[1] *Monthly Bulletin, New York City Department of Health*, August, 1913.

CHAPTER XIII.

MILITARY HYGIENE.

THE health and efficiency of an army are dependent upon the physical condition of the individual soldier and the hygienic condition of his environment, the nature of his food-supply, qualitatively as well as quantitatively; the nature of his clothing, and the nature and extent of his physical exercise.

The Recruit.—It is evident that the health and efficiency of an army rest fundamentally upon the physical condition of the recruit, and consequently great care is exercised in the selection of individuals for enlistment. The physical condition and endurance of the recruit are influenced directly by his age, height, weight, and general physical development.

The age of the recruit has an important influence upon his physical endurance and adaptability to the service. In men of eighteen to twenty years of age the ossification of the bones and the general muscular development are as yet incomplete, and therefore they are more liable to succumb to the strenuous duties of the soldier. In like manner, men over forty-five years of age frequently lack endurance because of beginning degenerative changes in the circulatory organs. It has been found that the most inefficient armies were those in which the largest proportion of the men were below twenty-two years of age, though it has also been found that young men are most easily trained and are more likely to follow orders without question. The age-limit, except in cases of re-enlistment, should, therefore, be from twenty-one to thirty-five years.

In peace the maximum age for cavalry is thirty years,

for all other arms, thirty-five years; the minimum for musicians, sixteen years, for all others, eighteen years. Volunteers are accepted between eighteen and forty-five, but men were drafted in the Civil War only between twenty and forty-five years. The unorganized militia are between eighteen and forty-five years. In the English army, according to Parke, men are enlisted from eighteen to twenty-five years of age.

The relative proportions of height, weight, and chest measurement of the recruit are valuable indicators of his general physical development, and, therefore, of his adaptability for the service.

The following table[1] shows the relative proportions of height, weight, and chest measurement as found in average men:

Height.			Weight.		Chest Measurement.			
					At Expiration.		Mobility.	
Feet.	Inches.	Cm.	Pounds.	Kg.	Inches.	Cm.	Inches.	Cm.
$5\frac{4}{12}$	64	162.5	128	57.9	32	81.2	2	5.0
$5\frac{5}{12}$	65	165.1	130	58.8	32	83.8	2	5.0
$5\frac{6}{12}$	66	167.6	132	59.7	$32\frac{1}{2}$	85.0	2	5.0
$5\frac{7}{12}$	67	170.1	134	60.7	33	86.3	2	5.0
$5\frac{8}{12}$	68	172.7	141	63.8	$33\frac{1}{4}$	86.9	$2\frac{1}{2}$	6.3
$5\frac{9}{12}$	69	175.2	148	67.0	$33\frac{1}{2}$	87.6	$2\frac{1}{2}$	6.3
$5\frac{10}{12}$	70	177.8	155	70.2	34	88.9	$2\frac{1}{2}$	6.3
$5\frac{11}{12}$	71	180.3	162	73.3	$34\frac{1}{4}$	89.5	$2\frac{1}{2}$	6.3
6	72	182.8	169	76.5	$34\frac{3}{4}$	90.8	3	8.8
$6\frac{1}{12}$	73	185.4	176	79.7	$35\frac{1}{4}$	92.0	3	8.8

It is, however, the manual states, not necessary for the recruit to conform exactly to the figures in the table. A variation of 10 pounds (4.5 kg.) in weight or 2 inches (5 cm.) in chest measurement (at expiration) below the standard given in the table is admissible, provided the applicant is otherwise vigorous and healthy.

The Surgeon-General gives the following directions for the examination of recruits:

"The minimum height of a recruit is at present fixed at 5 feet 4 inches for all branches of the service, although

[1] *Manual of the Medical Department of the Army*, edition of 1900, p. 101.

recruiting officers are allowed to exercise their discretion as to the enlistment of desirable recruits (such as band musicians, school-teachers, tailors, etc.) who may fall not more than ¼ inch below the minimum standard of height; the maximum height for the calvary service is 5 feet 10 inches; that for infantry and artillery is governed by the maximum weight, to which should be applied the rule for proportion in height.

"The minimum weight for all recruits is 125 pounds, except for the cavalry, in which enlistment may be made without regard to a minimum weight provided the chest measurement and chest mobility are satisfactory. The maximum for infantry and artillery is 190 pounds; for cavalry and light artillery, 165 pounds.

"The chest mobility—*i. e.*, the difference between the measurement at inspiration and expiration—should be at least 2 inches in men below 5 feet 7 inches in height, and 2½ in those above that height."

The height of recruits must be at least 165 centimeters; minimum chest measurement, 75 centimeters, with at least 5 centimeters expansion; and the weight 54 to 81 kilograms. In the cavalry service the maximum weight is 75 kilograms.

According to Parke, probably 63 inches at nineteen years of age, and 120 pounds weight, should be the minimum height and weight according to age, even in times of greatest pressure.

In France the weight is reckoned at the rate of 700 to 725 grams for each centimeter of chest circumference.

Any defect or deformity which is likely to interfere with the duties of a soldier will cause the rejection of the applicant. He must have free use of his limbs and be active and vigorous. The character of the feet and legs is a most important matter for investigation by the recruiting officer because of the nature of the service in which the soldier engages. Any defects or imperfect development of the feet and legs will probably be detected by the examining officer from the exercise in walking,

running, and jumping to which the applicant is subjected. The hearing must be normal and the vision without evident defect. The recruit must be "effective, able-bodied, sober, free from disease, and of good character and habits." The mere fact that the recruit presents himself for examination in ragged or filthy clothes, or is filthy in his person, is sufficient to cause his rejection. The most frequent cause of rejection of applicants is some form of defective development. For the year 1899 there were examined 70,311 men for enlistment in the regular army, of whom 47,899 were accepted, or 681.24 out of every 1000 examined. "Of every 1000 examined, 74.56 were rejected on account of imperfect physique, including overheight, underheight, overweight, and underweight; 41.43 for diseases of the eye, 38.06 for diseases of the circulatory system, 26.53 for diseases of the digestive system, 22.43 for affections of the genito-urinary system, 17 for venereal diseases, 9.61 for hernia; while 9.81 were rejected as generally unfit or undesirable, 3.74 as minors, 3.12 on account of bad or doubtful character, and only 1.32 on account of illiteracy, imperfect knowledge of the English language, or mental insufficiency." [1]

Training of the Recruit.—Physical Training.—In order to increase his endurance, as well as add to his general usefulness as a soldier, the recruit must be subjected to thorough physical training as well as training in the art of war before engaging in active warfare. Physical training, if conducted systematically, will greatly increase the endurance of the raw recruit. Without this preliminary training most men, however well proportioned they may be, will succumb to the arduous duties of active warfare.

The recruit should be instructed in swimming, not only because it is a most useful physical training, but also because it is an acquirement that may be of the greatest service in his calling. Dancing, fencing, and general gymnastic exercises are of great value in training

[1] *Report of the Surgeon-General*, p. 27, 1900.

the coördinate movement of muscles, as well as in aiding in the uniform development of the body and in increasing the general physical endurance. Exercises in singing are valuable in improving the lungs and in developing the breathing capacity. Any exercise that aids in improving the general physical condition of the body should be made use of in the preliminary training of the recruit.

Moral Training.—The great danger from vice in the army arises principally from the fact that large numbers of men are brought together, and are, in times of peace, compelled to spend a portion of their time in comparative idleness. The utilization of definite portions of each day in perfecting the men in their knowledge of the military art will, in large part, prevent vice, and gives at the same time healthful occupation to the mind, thus preventing home-sickness. The soldier should also be instructed in other lines of useful knowledge, such as cooking, washing, and sewing, so that he may contribute toward the general comfort of the army as well as his own welfare.

Food of the Soldier.—Under present laws and regulations the soldier may have any variation of his diet within certain money value limits which his officers consider necessary for his well-being. His ration is fixed by law, but his diet depends on the intelligent supervision of company officers and the ability of company cooks. Major Howard[1] states that "the diet of the soldier is what the company commander and his first sergeant and cook may choose to make it, the materials being amply provided by the official ration."

The soldier's ration consists of the following: 342 grams of pork or bacon, or 567 of fresh beef; 454 of hard bread, or 566 of flour; 68 of beans or peas, or 45 of rice or hominy; 45 of green coffee; 17 of salt; 68 of sugar; besides pepper, vinegar, and, at times, tea instead of coffee.

The food should be thoroughly cooked, and free from

[1] *Surgeon-General's Report*, p. 174, 1900.

fermentative or putrefactive changes. Ripe fruit may be eaten in moderation, but green or over-ripe fruit should be avoided, because these give rise to disturbances of the digestive organs.

With such ample provision of materials it has generally been found possible to adapt the diet to any climatic conditions to which our army has been subjected in the past few years. No doubt some difficulty was experienced in supplying the full complement of fresh meat and vegetables in the tropics at all times, on account of the great distance from the base of supplies, but, in general, there appears to have been little real inconvenience.

There has been considerable discussion as to the suitability of the ration to tropical conditions, some claiming that an excess of fat and a deficiency of carbohydrates in the form of fresh vegetables and fruit was supplied. There is, however, provision in the law allowing commutation of the rations, thus permitting the purchase of food in the local markets, and in this manner any defects in the materials supplied can be remedied to advantage.

Unless the duties of the soldier in the tropics are arduous, thus necessitating a diet rich in proteids, the use of a greater proportion of vegetables and ripe fruit than is the custom in colder climates would serve to reduce the danger from disordered gastro-intestinal function in large part. Along with the use of pure water such a diet should serve to lessen the suffering from diarrhea and dysentery.

New Ration for Soldiers.—Since the unpleasant results during the Spanish war from the use of canned beef in the tropics the Government has substituted fresh meats for the troops in the Philippines. At considerably greater expense the Government has bought refrigerated beef in Australia for the army in the Philippines, but it is only available for troops stationed at seaports or within easy reach inland. It will keep twenty days in good condition for use, but it is not an ideal meat ration for active field service where troops are on the march. The

most practical method of maintaining a meat-supply for moving troops has been to drive cattle along with the marching column.

The trial of a new ration called "roast-beef hash" seems now likely to solve some of the problems of subsistence for men in the field. This is a canned beef that has been thoroughly cooked and mixed with chopped and cooked potatoes and onions. It will keep indefinitely and is said to be most appetizing. The men like it, and the first trial has proved so successful that a larger amount will be shipped. It is packed in boxes and can be transported readily and served out to each mess quickly, supplying on occasion a complete meal ready cooked. On forced marches or in a country where a fire is not desirable it is a very convenient food. It is adapted to rapid marching, where it is impracticable to take along a supply train, pack animals being able to carry a considerable amount, and in case of necessity each man can put a day's supply in his haversack.

Murlin[1] reports on a food survey of 227 messes distributed among 40 training camps in America. Fresh meat and bread are issued daily by the camp quartermaster, while other articles of food are distributed every ten days on requisition by the mess sergeant. The total amount of energy supplied in the food is a little under 4000 calories, the waste about 300 calories, and the amount consumed about 3700 calories. The distribution of calories consumed is 14 per cent. protein, 31 per cent. fat, and 55 per cent. carbohydrate.

Mason,[2] in discussing the field ration, speaks of a ration carried by a number of officers and tried with satisfaction. It consisted of the following:

Two 1-pound tins of hard bread.
Two 11-ounce tins of baked beans.
One meal can of sliced bacon (1½ pounds).
One condiment can containing
  Compartment *a*—crushed soup cubes.
  Compartment *b*—soluble coffee and sugar mixed.

[1] *Jour. Amer. Med. Assoc.*, Sept. 21, 1918.
[2] *Military Surgeon*, xlvi, 1920, 182.

This ration could be eaten uncooked, if necessary, and proved fairly palatable. It yielded the following energy values:

Bread	3594	calories
Beans	820	"
Bacon	4858	"
Sugar (3 ozs.)	348,	'
Total	9620	calories, or 4810 calories per day.

The protein content of the ration was 186 grams, or 93 grams per day. This gave a diet of 84 grams of protein or 4810 calories.

The field ration must be as light as possible, and it must be so packed that it is easily transported. All the containers should be weather-proof. The shape, size, and the materials of which the containers are made are all matters of great importance. So far tin appears to be the best material for the containers. Square containers pack more readily and securely than any other shape. The size of the container should be adapted to hold at least two days' supply of each kind of food furnished to each man.

Clothing of the Soldier.—The clothing of the soldier requires intelligent supervision in order to adapt it to the climate of the locality in which he is serving as well as to seasonal variations.

Underclothing.—Light woollen underclothing should be supplied, because it takes up moisture from the skin very readily, and thus protects against chill after exercise. In the tropics coarse mesh linen underclothing is preferable, because it does not retain the moisture as does woollen underclothing. The stockings, on the other hand, should be composed of about equal parts of cotton and wool. Woollen stockings are apt to cause sweating of the feet, and thus induce a tender condition of the feet which is likely to produce discomfort or even suffering. Cotton stockings are apt to be cold, and are therefore not suited

for colder climates. Olive-drab woolen shirts should be supplied except for service in the tropics, where a cotton shirt may be substituted.

Outer Garments.—The uniform should be adapted to the occupation and to the climate. In colder climates woollen garments should be supplied, the weight of the goods being regulated according to the locality. In the tropics, and during summer in the temperate zone, the garments should be made of materials which allow of the free circulation of air. The olive-drab cotton cloth now generally in use for the uniform supplied to troops in the tropics and for wear during the summer in the temperate zone has proved quite satisfactory.

The color of the soldier's uniform is of an olive-drab shade. The winter uniform is woolen cloth and the summer uniform of cotton. The headdress conforms in color to that of the uniform.

The color of the uniform is of great importance not only on account of its heat-absorbing powers and the facility with which it allows the heat of the body to pass off, but likewise because of the extent to which it renders the soldier visible at a distance. Red is the most conspicuous color, white is next in order, while gray is least conspicuous. The olive-drab woolen uniforms are very well adapted from this standpoint. This is a point that should be considered by the State in order to conserve the life and safety of its soldiers. During the conflict in South Africa the British officers are reported to have suffered disproportionately on account of the color of their uniforms.

The head-covering is of great importance, especially in the tropics, where the head and face should be shaded from the fierce rays of the sun and against rain. The hat worn by the troops in the tropics meets these points fairly well. It is light, and allows free circulation of air, thus limiting the danger from sunstroke.

The shoes should be adapted, as near as may be, to the

feet of the individual wearing them. In order to be able to meet this demand satisfactorily, the State should supply the common sizes and shapes of sole, and, besides this, make to order the shoes of those that cannot be fitted properly from stock. A great deal of discomfort and suffering may be avoided by such a course, besides enhancing the endurance and efficiency of the soldier.

While on the march each soldier carries also his blanket and waterproof, and in cold climates his overcoat. These articles of clothing are made up into a roll, together with the toilet articles, and this is slung over the shoulder. It is not likely that the knapsack formerly in use will again find favor. It gave rise to discomfort, and at times proved positively injurious because it had to be buckled on firmly and therefore impeded the free movements of the soldier's arms and chest.

When the soldier's clothing or bedding becomes damp from exposure to rain or heavy dews, it should be dried in the sun or by fires at the first opportunity that presents itself.

The following is Major Meacham's opinion with regard to the soldier's clothing for field-service in the tropics, based upon his experience in northern Luzon, P. I.:

"The clothes must be loose and comfortable. On the march, part woollen should be worn next the body. Experience during the past wet and dry seasons shows that the clothing now furnished is fairly well adapted to this climate. The supply at the depots has been sufficient. The shoes and socks give entire satisfaction. For the march the light woollen sock is preferable.

"The recent issue of campaign hat, with corrugated sweat-bands and ventilation in the sides, possesses advantages not obtainable in other forms of headgear for constant use and all-around field-service. It is far superior to the straw hat, and, during the rainy season, to any cork or pith helmet. The latter requires more or less care at all times, both on and off the head.

"A part woolen undershirt is necessary to protect the body from sudden chilling. The cotton or nankeen undershirt is cold, clammy, and sticks to the body while in profuse perspiration. This is especially noticeable during the five minutes' rest given hourly on a regular march.

"The lighter issue of the blue flannel shirt answers fairly well at all times, but is objectionable in some respects. Its color more rapidly absorbs the heat, and can be distinguished a long distance, making the wearer a good mark for the enemy. A gray flannel shirt of medium weight is preferable. The flannel shirt has the advantage of keeping the body warm, even when wet, night and day. The soldier prefers to wear the blue flannel shirt on the march, with no undershirt, the sleeves rolled up, open in front, and the collar well rolled back. It is thus made very comfortable, the campaigner readily becoming accustomed to the sun's rays. One great objection to this shirt is its irritating effect on the skin. On returning to camp at night the soldier puts on the cotton undershirt as a protection against this irritation.

"Of the clothing furnished at present for active campaigning I have found that the light-gray woollen undershirt of light weight, with an overshirt of chambray or gingham, gives comfort and satisfaction. Personally I have found the most comfort from the gray outing flannel of medium weight, worn with no undershirt. This same material of a khaki color would be still better. It prevents chilling; is never too warm, nor sticks to the body, but absorbs the perspiration and dries readily. A cotton undershirt worn under this while in camp gives one the greatest amount of comfort, and is sufficiently warm for the night. As the nights here are usually cool, sufficient covering for the abdomen must be worn. For this the blue flannel shirt answers well; in fact, it has become quite customary when not on the march, but lying in camp, for the soldiers to wear the blue flannel shirt at night. The coolness of the night while lying down is severely felt upon the abdomen often enough to keep one

awake and interrupt his rest. Even a slight covering is a help, and for this the flannel belly-band is worn. The neglect of this is undoubtedly the predisposing if not the actual exciting cause of many of our intestinal ailments.

"The white jean drawers answer all conditions at all times; they are loose, comfortable, and safe.

"The khaki fatigue uniforms are excellent.

"During the wet season the large ponchos now furnished are of more service than the rain coat or mackintosh. They protect sufficiently well and are not as hot as the mackintosh; besides they serve as a blanket or covering at night."

Protection Against Shell Fragments.—The protection of soldiers has received some consideration during the European War. Metal armor is generally considered as the most serviceable. Steel armor weighs about 7 pounds and has been suggested for the protection of the soldiers occupying the advanced positions. Silk has also been found to serve quite satisfactorily, but silk armor of sufficient thickness to afford protection weighs about as much as steel, and it is regarded as inferior to steel as a protective.

Protection Against Poisonous Gases.—The employment of different poisonous gases by the enemy during the European War compelled the wearing of gas masks containing materials that absorbed the gases from the inspired air. Chlorin gas and phosgene gas have especially irritating effects on the mucous membranes. This seems to be the principal danger from these gases. On the other hand, "mustard gas," dichlorethyl sulphid, has, in addition to its highly poisonous action on the mucous membranes, also a destructive action on the skin. "Mustard gas" causes vesicular and escharotic lesions of the skin and mucous membranes, especially of the conjunctiva, mucous membranes of the respiratory tract, and externally it involves the axilla, penis, scrotum, perineum, inner surface of the thighs, the flexor surface

of the joints, and the buttocks. In many cases there is vomiting, diarrhea, hemoglobinuria, albuminuria, and often enlargement of the lymphoid tissue throughout the body. Extensive blood changes follow, as polycythemia, leukocytosis, increase of blood-platelets, and increased coagulability.

Camps.—Tents.—The tents used in the army are the hospital tent, the officers' wall tent, the Λ-tent, and the shelter tent, which is a modification of the last. Soldiers give the preference to the shelter tent, which is light, each man's piece weighing only 1.18 kilograms. Two pieces being joined together by buttons and buttonholes, and thrown over a ridge pole supported by four uprights, and the four corners fastened to pegs driven into the ground, form a tent 1.2 meters high, 1.65 meters long, and having a spread at the base of between 1.8 and 2.1 meters. Such a tent will form a comfortable shelter for two men, unless there should be strong winds or driving rains, when the ends should be closed by blankets or an extra piece of shelter tent. The uprights and ridge are steadied by short guy ropes, one of which is furnished with each piece of tent.

Location of the Camp.— The camp should not be located on a spot that has recently been used for the same purpose. Camp sites should also be frequently changed, in order to avoid the effects of soil pollution which might result from long-continued occupation. The camp site should be selected with reference to several important particulars. The soil of the locality should be dry, sandy in character, and well drained. The site should also be so located as to afford a plentiful supply of pure and wholesome water. Too much stress cannot be laid upon this point. Low-lying, damp, or marshy localities should be avoided for obvious reasons.

The camp should be laid out in regular order with streets, so as to provide ways of passing freely through the camp. The camp should be as compact as will be permissible with health and cleanliness.

A trench, at least 10 centimeters in depth, should be dug around each tent, so as to exclude surface water, and this should lead, with the trenches from the other tents, into a larger one for each street, so as to conduct the rain-water from the camping-ground.

Sanitary Policing of the Camp.—The camp streets are cleaned regularly every day and all rubbish burned as promptly as possible. All kitchen refuse should be collected twice a day and removed from the camp-grounds or buried in trenches dug for the purpose. The tents should be aired each day by opening the doors and raising the walls after the men have left them in the morning. All bedding should likewise be exposed to the air every day unless the weather is such as to prevent it.

Water-supply.—There should be an abundant supply of pure water for all purposes for which it is needed. Where the wholesomeness of the water is doubtful, some method of purification should be provided. For this purpose the Forbes portable water sterilizer (Fig. 55) is frequently employed.

This apparatus is in very common use in the various army camps in the tropics, and the universal report is most favorable as to its efficiency in preventing the development of typhoid fever and diarrheal diseases among the troops. Even in localities where typhoid fever prevailed the introduction of the apparatus and the exclusive use of boiled or sterilized water arrested the outbreak.

A board of army surgeons, consisting of Majors Reed, Shakespeare, and Vaughn, appointed for the purpose of testing various types of apparatus submitted to the war department for use in sterilizing water in the field, report that "all living micro-organisms, except a few spore-bearing bacteria, are destroyed by the degree of heat attained during the passage of the water through the apparatus. The disadvantage of the escape of a few spore-forming bacteria through this apparatus is considered to be of no practical importance by the Board." They also

found that "there is no loss of the natural gases during the passage of the water through the apparatus."

The treatment of water with disinfectants has received considerable study, and the hypochlorites have been found valuable for this purpose. Sodium peroxide has also been tried and found to yield a safe water.

FIG. 55.—Forbes' portable water sterilizer, army type.

Lyster Bag.—One of the easiest and yet effective methods of purifying water for mobile troops in the field consists of treatment of the water in Lyster bags with calcium hypochlorite. The Lyster bag can be folded for carriage and weighs 7½ pounds. It is composed of specially woven flax sewed to a galvanized iron ring from which the bag is suspended. Near the bottom of the

bag are five nickel, self-closing faucets. The bag has a capacity of 36 gallons. Calcium hypochlorite is furnished in glass tubes each containing 1 gram of the disinfectant. This gives an available chlorin content of the water in the bag of about 2 parts per 1,000,000. If deemed desirable the excess of free chlorin in the water may be neutralized by adding sodium thiosulphate to the water after sufficient time has elapsed to bring about disinfection. If the water is turbid it may be treated at the same time with a small amount of alum solution. This will cause the matter in suspension to subside and leave the water clear.

Provision should be made of ample opportunities for bathing. In the absence of large bodies of water in the vicinity of the camp permitting the soldiers to engage in swimming, shower-baths, at least, should be supplied at convenient points on the camping-ground.

Latrines.—The latrines should be situated from 140 to 150 meters to the leeward of the camp. A deep and narrow trench should be dug for the purpose. It must not be too wide, or it will require more earth to cover the excreta. At least three times each day the excreta should be covered with earth to a depth of 2 to 3 decimeters, or with slaked lime. The dry earth readily absorbs the putrifying material and thus renders it inoffensive. The bacteria in the soil decompose the organic matter contained in the excreta, thus rendering it harmless. This procedure will protect the excreta from flies and insects, and limit one source of danger of general infection should there be unrecognized cases of typhoid fever in the camp. The excreta of all cases of typhoid fever and dysentery should be disinfected at once. They should never be thrown into the trenches without this precaution. The excreta in the trench may also be burned daily by pouring kerosene upon them and applying the torch. In the tropics, during the rainy season, the dry-earth closet is being used for hospitals and camps in towns. The excreta

are collected in galvanized vessels, covered with dry earth, and emptied at frequent intervals. New sinks should be dug when the old ones are filled to within 6 decimeters of the top, the old sinks being completely filled with earth.

Barracks.—Besides healthful sites, the essential conditions of barracks are dryness, warmth, light, amount of floor space, and air-supply.

In the squad-room each man should have at least 30 cubic meters of air space and 465 square decimeters of floor space, and south of 36 degrees north latitude the proportions should be 40 and 665, respectively.

There should be more space allowed if the barracks are constantly occupied, because the dimensions given are

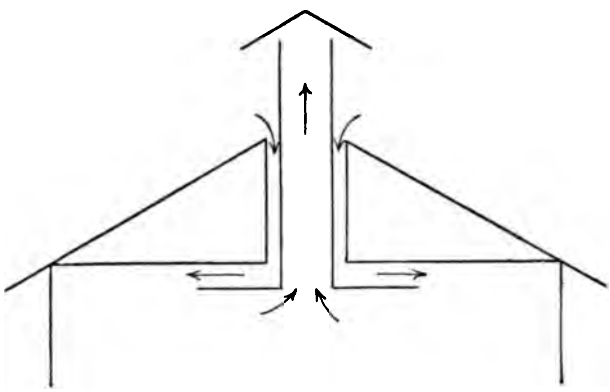


FIG. 56.—Diagram illustrating ridge ventilation.

too low for constant occupation during active exercise. The official recommendations for English troops in India range from 75 to 150 cubic meters of air space, and from 620 to 1240 square decimeters of floor space.

The squad room should be not less than 35 decimeters nor more than 42.5 decimeters in height, and preferably about 70 decimeters wide. Excessive height and width should be avoided because of greater difficulty in efficient ventilation.

Ridge ventilation is perfectly satisfactory for barracks,

or it may be accomplished by means of double inlet and outlet tubes in the roof (see Fig. 56), so constructed that the fresh air enters through the outer tube and the vitiated air takes its exit through the inner tube.

There should be ample provision for bathing, and the water supplied as pure as can be obtained. If its purity is open to question, it should be purified by disinfection, boiling, or filtration.

The latrines require careful attention. If it is possible to use water-closets, these will give rise to least difficulty. If the dry-earth closet system is employed, the receptacles should be emptied at frequent intervals. The latrines should not be near the kitchen or mess-room, nor near the sleeping-quarters of the troops.

The kitchens should be in separate buildings from the sleeping-quarters, or at least removed from them as far as possible.

When numerous cases of tonsillitis occur in barracks, deficient ventilation may usually be suspected. The accumulation of infective dust, along with vitiated air, in barracks is frequently the predisposing cause of tuberculosis and pneumonia among troops.

Marches.—The effects of marches are dependent upon the distance covered, the rate of travelling, the load carried by the soldier, the condition of the weather, and the character of the roads. An important influence upon the soldier during long marches is the length of the step taken and the number of steps per minute.

At the end of each hour a rest of at least five minutes should be allowed. This will permit the fatigued soldier to recuperate, at least partially, and increases his endurance to a very large extent. Whenever possible, marches should be made before ten in the morning or after five in the afternoon if the weather is warm, and the troops should be allowed to rest during the hottest part of the day.

The canteens are to be filled with water or tea before beginning a march, but no fluid should be drunk while marching, or as little as possible, and then only in small quantities at a time.

Under ordinary conditions, both in cold and hot countries, the men are healthy on the march. But marches are sometimes harmful:

1. When a single long and heavy march is undertaken, when the men are overloaded, without food, and perhaps without water.

2. When the marches, which singly are not too long, are prolonged over many days or weeks without rest.

3. When special circumstances produce disease.

The diseases from which the soldiers of the United States suffer most commonly, in time of peace, are: venereal diseases, tonsillitis, acute and chronic bronchitis, diarrhea and enteritis, influenza, malarial fevers, rheumatism, measles, mumps, tuberculosis. The diseases which prevailed during the Spanish-American War were: malaria, dysentery and diarrhea, typhoid fever, respiratory, and venereal diseases. The prevalence of these diseases varied with the localities in which the troops were employed.

The diseases which cause the greatest number of deaths in soldiers in time of peace are: tuberculosis, pneumonia, heart disease, typhoid fever, nephritis, measles, and appendicitis. Since the compulsory immunization of all recruits has been enforced typhoid and paratyphoid fevers have practically disappeared from the army. Cholera has been kept under control in the armies of Europe by immunization of all the soldiers.

Tuberculosis has become a very serious problem in France and some of the other European countries since the beginning of the war. The disease prevails not only among the troops but also in the civil population. Several factors are responsible for this condition, namely, neglect of precautionary measures against the disease before the war as shown by the high death-rate from tuberculosis, especially the lack of facilities for the treatment of either incipient or advanced cases in hospitals, sanatoria, or dispensaries; the unsanitary housing of the

civil population and of the troops in the trenches; and the malnutrition induced by the exigencies of the war.

Tuberculosis among the troops can be minimized by careful physical examination of all recruits and by greater attention to the housing of the troops, especially while they are not serving in the trenches.

Pneumonia is also a serious disease among troops whenever they are exposed to the conditions prevailing in the trenches, and especially where they are housed in unsanitary quarters after leaving the trenches. Where troops are confined in improperly ventilated barracks or in temporary quarters that are not so constructed as to permit thorough ventilation pneumonia usually prevails and claims a high toll.

Venereal diseases are always common in troops for a number of reasons and require the constant vigilance of those in authority to keep them under control.

Camp Diseases.—The importance of hygienic measures in the army and the destructive effects of diseases are clearly shown by the records of the Civil War 1861–65, when the casualties of battle were exceeded fourfold by the deaths caused by diseases, the most important and fatal of which were pneumonia, typhoid fever, diarrhea, and dysentery. During the Spanish-American War, in spite of the great advancement in our knowledge of the etiology and modes of dissemination of typhoid fever, a very large proportion of the army was rendered useless for several months owing to the prevalence of this disease alone.

The close companionship entailed by the military service and the neglect of individual cleanliness are largely blamable for the wide dissemination of typhoid fever, diarrhea, and dysentery. Under these conditions it would seem a much greater degree of personal cleanliness is necessary than in private life. Another factor to be considered is the large number of mild cases, the so-called "walking" cases. Aside from this the influence

of infected dust, the agency of flies and insects, must also be taken into consideration.

Antityphoid Vaccination.—The practise of antityphoid vaccination, first introduced into the English army by Sir A. E. Wright, and since adopted by the armies of nearly all the world powers, is, beyond question, limiting the incidence of the disease and reducing the mortality. The adoption of this method of protection for the soldiers of the United States army has almost eliminated the sickness-rate and the death-rate from typhoid fever.

Pfeiffer and Kolle, in Germany, and Sir A. E. Wright, in England, in 1896, demonstrated that it is possible to immunize human beings against typhoid infection by the injection of extracts of Bacillus typhosus or by the injection of the bacilli killed by heating above their thermal death-point.

Wright vaccinated a portion of the British army sent to Africa during the Boer war, and subsequently some of the soldiers sent to Egypt and portions of the forces in India were also vaccinated. The value of these vaccinations was shown in the lowering of the incidence of typhoid fever among the vaccinated troops as compared with those not so protected, and also in the lowering of the death-rate among the vaccinated as compared with that among the unvaccinated.

Antityphoid vaccination in the United States army was first carried out by Major F. F. Russell early in the year 1909. At first vaccination was voluntary, but was made compulsory March 9, 1911, for the troops sent to Texas and California along the Mexican border. June 9, 1911, vaccination was made compulsory for all recruits, and September 30, 1911, for all persons in the army under forty-five years of age.

The vaccine employed in the United States army and navy is prepared from a single culture (Rawling's) grown in agar flasks for eighteen hours. The growth is washed off in a small quantity of sterile salt solution and the suspension heated in a water-bath at 53° to 54° C. for one

hour. To this is added 0.25 per cent. of trikresol, and the suspension diluted with salt solution until a concentration of 1,000,000,000 bacilli to the cubic centimeter is obtained.

The vaccine is tested as to its sterility, purity, and for the presence of tetanus bacilli.

The vaccine is administered in three doses of 500, 1000, and 1000 million bacilli at intervals of about a week.

The following table[1] shows the occurrence of typhoid fever (1901 to 1912) for the entire United States army, officers and enlisted men, at home and abroad:

YEAR.	Mean strength.	Cases.		Deaths.		Percentage of total cases.	Occurring among those who were vaccinated.	
		No.	Ratio per 1000 of mean strength.	No.	Ratio per 1000 of mean strength.		Cases.	Deaths.
1901	81.885	552	6.74	74	.88	13.0		
1902	80.778	565	6.74	69	.85	12.2		
1903	67.643	348	5.14	30	.44	8.6		
1904	67.311	293	4.35	23	.33	7.8		
1905	65.688	206	3.14	20	.30	9.7		
1906	65.159	373	5.72	18	.27	4.8		
1907	62.523	237	3.79	19	.30	8.0		
1908	74.692	239	3.20	24	.31	10.0		
1909	84.077	282	3.35	22	.26	7.8	1	0
1910	81.434	198	2.43	14	.17	7.1	7	0
1911	82.802	70	0.85	8	.10	11.4	11	1
1912	88.478	27	0.31	4	.044	14.8	8	0

During the European War there were comparatively few cases of typhoid and paratyphoid fever in the army. Most of those that did occur may be accounted for by the fact that the infection developed before the soldier had been fully immunized. Where the disease occurred in soldiers a year or more after immunization it is probable that the immunity had been lost, as studies on the agglutinins in the blood of vaccinated individuals show that eighteen to twenty-four months after vaccination some individuals have lost all immunity.

In the United States Navy[2] antityphoid vaccination was made compulsory January 1, 1912, and the degree of

[1] *Russell's Amer. Jour. of Medical Sciences,* December, 1913, p. 803.

[2] *Ann. Rept. Surg. Gen.,* 1912, p. 116.

protection has been equal to that experienced in the army.

Pneumonia and acute bronchitis are more prevalent during the winter months, and these are traceable to exposure, dampness, imperfect nutrition, insufficient clothing, and inefficient ventilation of quarters, these being the most common predisposing factors. Rheumatism also is favored by the same predisposing causes.

In certain localities malarial fevers also prevail to a considerable extent among soldiers. This has been the case with our soldiers in the tropics. The preventive measures which would tend to render a malarious locality healthful are draining of damp soil, pouring oil upon all stagnant bodies of water, the protection of the soldier by means of mosquito-bars wherever possible, and the avoidance of exposure after nightfall.

In camps composed of recently enlisted soldiers measles is very likely to make its appearance. Thus far no definite mode of prevention can be outlined against this disease except the prompt isolation of cases as they appear.

Tuberculosis is also prevalent among soldiers. This is the case in both camp and barracks, though in the latter it is encountered most frequently.

Meningitis occurs among the new recruits, but fortunately this disease can be controlled by the prompt isolation of the patient and the bacteriologic examination of all contacts for carriers. By treating the carriers in isolation wards the disease can be brought under control.

Mumps is a disease that is encountered very commonly among new troops in camps. Fortunately, this is ordinarily not a serious disease, and prompt isolation of the patient and segregation of the contacts for the period of incubation—ten to fourteen days—will aid in controlling the disease.

Diphtheria occurs among recruits and to a less degree

among seasoned troops. This disease can be controlled by prompt isolation and treatment of the patient, the bacteriologic examination of all contacts for carriers of the diphtheria bacillus, the application of the Schick test to all contacts, and the active immunization of all those showing a positive Schick reaction.

Diseases of the heart and blood-vessels are frequent as the result of the strenuous duties of the soldier. Long and forced marches result in the exhaustion of those with a weak circulatory apparatus.

Venereal diseases are always prevalent among soldiers. The prevention of these diseases is a most difficult matter, because it is impossible to control such a large body of men in their moral and social relations. Some good may be accomplished by banishing all known prostitutes from the neighborhood of the camp.

Scurvy is far less frequent than formerly, though it is not unknown even at the present day. This condition may be prevented by proper regulation of the food-supply, since it is known to be a disease due to improper nutrition. Fresh vegetables and ripe fruit are the most serviceable in this respect. In the absence of sufficient supplies of these, the use of lime-juice and vinegar will prove of great value.

Foot Inspection.—The frequency of foot inspection varies with conditions. When the men are not marching a great deal one such inspection every fortnight should meet all needs. In the field, or when troops are undergoing hard marching, such inspections should be made daily, so that trifling defects and injuries may be given prompt attention. The inspection is made after the feet have been washed. In garrison the men stand in bare feet at the foot of their cots until the officer has passed. In the field they sit on the ground in front of their tents, or at such other convenient place as may be available. As the officer passes, accompanied by the

non-commissioned officer in charge, he notes the condition of the feet, especially in regard to recent injury, but also with reference to defects of longer standing. When attention to the feet is required the officer gives the necessary directions to the soldier, in the presence of the non-commissioned officer, who becomes responsible for their being carried out. Before a march is undertaken by foot troops company commanders will personally inspect the bare feet of their men. While on the march they will personally see each day that the men wash their feet as soon as possible after reaching camp, prick and evacuate blisters, and cover such blisters and excoriations with zinc oxid plaster, applied hot, then dust the feet with foot powder, and put on clean socks. (General Orders, No. 26, 1912.)

Body Inspection.—The entire body of every man in the army is inspected twice a month by a company officer and a medical officer, careful search being made for any heart lesion, hernia, venereal disorder, skin disease, eczema, etc. This is in order that any physical defect that might be concealed by clothing or by the improper modesty or wilfulness of the enlisted man may be carefully noted, cared for, and reported.

These inspections are in addition to frequent inspections, at times unknown beforehand, to determine the presence of venereal disease. These unannounced inspections should be made at such times as the men will not have an opportunity to clean up and thereby hide the evidence of venereal infection.

The incidence of venereal diseases among soldiers has been reduced through the active campaign for the control of these diseases which has been in operation since 1913. The more important of these preventive measures are required lectures to enlisted men to be given by medical officers explaining the provisions in Army Regulations relating to venereal diseases; the description of the venereal diseases with special emphasis

upon those features that incapacitate their victims as soldiers, and threaten their future efficiency and happiness as citizens, and the effects upon wife and children. The restriction of leave to daylight hours does much to discourage prostitution and brings the men who have been exposed back to camp soon after sexual contact, so that prophylaxis is made more effective. The use of prophylactic treatment is undoubtedly useful in limiting infection, especially so the earlier the treatment is applied following exposure. The exclusion of prostitutes from camps and neighboring towns, as far as they can be detected, serves a most important purpose in limiting the incidence of venereal diseases.

CHAPTER XIV.

NAVAL HYGIENE.

THE term *naval hygiene* usually includes all that relates to maritime life, whether relating to war or to commerce. In a certain sense the application of hygienic measures to such a small and isolated community as found in a vessel is extremely simple. In modern vessels it is far easier than in those of even a decade ago. The improvements in construction, arrangement, and equipment have had a most salient influence upon the health of sailors and marines, and upon the comfort of passengers.

Though there have been important advancements in the construction and arrangement of vessels, it is still a difficult matter to supply pure air in sufficient quantities, because with the advancement in equipment there has been no relative increase of the air space available for each person. The air space on shipboard being necessarily limited, the average space per individual can only be indirectly increased by reducing the number of seamen to the lowest point permissible.

The vessel should be as large as possible with reference to the purpose for which it is intended, the arrangement of machinery and cargo should be such as to economize the utilization of space, and the size and location of the cabins should be regulated so as to afford a maximum amount of space for each person. The arrangement of cabins should be made in such a manner that it may be possible to secure complete isolation of any cases of infectious disease at some point removed from the seamen in their usual duties. The amount of space provided for each seaman is greater than had formerly been the case, but even at the present time it falls below theoretic

standards. The hospital cabins should be of greater space, because they are occupied during every hour of the day. These quarters should not be located in the forecastle, but at some point as far removed from the noise of the machinery as possible.

The cubic space allotted to each marine on war vessels has not been accurately determined and no data are available on this point. The fact that marines sleep in hammocks may be the cause of supplying a somewhat greater cubic space for them than for sailors on vessels of commerce where hammocks are not employed.

Ventilation.—In modern vessels propelled by steam the introduction of forced ventilation by the use of fans or steam jets is a comparatively easy matter. In this manner a definite air-supply can be assured, either by propulsion of fresh air or extraction of the vitiated air. By this method the defects arising from the small amount of air space usually supplied can be remedied to a great extent.

According to information derived from the Bureau of Construction and Repair of the Navy Department of the United States, "All ships of war are ventilated on two principles, natural and artificial. Natural ventilation is obtained through hatches, ventilating ducts, and other openings leading directly to the compartment to be ventilated, and depending upon a supply of air through cowls which are turned toward the wind. All living-spaces are further ventilated artificially, either by means of steam or electric blowers, which supply the air to or exhaust it from the compartments in question. Some compartments are fitted with both supply and exhaust blowers, but in general only one system is fitted, a natural exhaust being obtained through the hatches or other openings into the compartment.

"No rules can be given for the cubic meters of space allowed per man. This is entirely dependent upon the design of the ship and the number of men carried. The design of the ventilating system, however, is such as to

renew the air in various spaces in certain intervals of time, which may be stated approximately as follows: General crew space, the air to be changed once in eight minutes; officers' quarters, once in twelve minutes; engine-room or steering-engine room (where the air is hot and vitiated), once in two minutes; dynamo-room, once every three-fourths of a minute.

"The supply of air to a compartment depends not only on its capacity and the number of men in it, but also upon the temperature, which in some parts of the ship is excessively high, and in others is naturally low. No figures on efficiency are available."

Dr. Coppinger[1] states that "the question of air space and ventilation, as applied to men-of-war, has always been a difficult problem, and the progress of modern naval architecture, necessitated by altered conditions of warfare, tends in many ways to make its solution more difficult of attainment. Among these conditions may be mentioned (1) the very great amount of air space occupied by machinery and stores connected with torpedo work, and (2) the introduction of water-tight bulkheads. These latter partitions are a great source of difficulty in respect to obtaining complete circulation of air throughout the ship.

"The introduction of the turret and barbet system of construction into battleships, with the consequent reduction and almost complete abolition of apertures for natural ventilation by means of ports and hatchways, has rendered necessary a very general introduction of artificial ventilation by means of rotary fans, to supplement artificial ventilation by means of funnel and funnel casing."

In order to cool the air between decks of vessels while in the tropics it has been suggested that this might be accomplished by the aid of compressed air. This may be utilized both as a source of motion for propelling the air and also to abstract heat when undergoing expansion.

The cubic air space per man on the submarines is 300

[1] *Trans. Seventh International Congress of Hygiene.*

cubic feet. Soda lime purifiers are employed to absorb the carbon dioxid from the air. During the most protracted periods of submergence on patrol—eighteen hours—there is a gradual reduction of the oxygen content of the air to about 15.5 per cent. This did not give rise to any physiologic indication of oxygen depletion. In emergency the compressed air-supply can be drawn on to increase the oxygen content of the air. The condition of the air was kept agreeable by the use of fans in each room. As long as the air is kept in motion no unpleasant sensations or effects are experienced.

The chief complaint among the officers and men is a mild middle-ear catarrh. This condition is believed to be induced by the noise from the engines and to a slight pull on the ear drum by the method of air supply to the engines through the conning tower. This brings about a slight alternate air suction and release throughout the boat. Frequently a history of previous injury or ear trouble can be detected.

Eye affections occur, especially eye strain, which is believed to be due to the excessive use of the eyes, to defective lighting, to refractive errors, and to glare.

Intestinal stasis was induced by the lack of muscular activity. The use of bran bread and of vegetables to supply the required amount of roughage in the food are beneficial.

The continued service induced a gradual deterioration of the officers and men, as indicated by loss of weight, pallor, the expression, and the general loss of tone. Two or three days are required for complete recuperation.

Heating of the Vessel.—The application of steam to navigation makes it possible to utilize the exhaust steam for purposes of heating. This precludes the attempt to heat by any other methods, and affords a safe and satisfactory solution to this problem, which formerly gave rise to such great difficulties.

"The problem of heating the air supply of ships in cold weather without reducing the relative humidity of the air in living compartments to a percentage conducive to the development of nasopharyngeal disorders has not yet been solved. At present sanitary reports indicate that the old system of delivering cold air through blowers and relying upon steam radiators for heat is preferable from the standpoint of comfort." (Ann. Rept. Surgeon-General, U. S. Navy, 1919, p. 353.)

Lighting.—The employment of electricity on all large modern vessels makes it possible to utilize this method of lighting; thus a great factor in the vitiation of the air in certain parts of ships is removed.

Cleansing the Vessel.—The excessive use of water for purposes of cleansing should be prohibited. It was formerly the custom to keep the floors constantly soaked by the frequent washing of the ship, thus giving rise to a most unhealthful condition from dampness. A satisfactory degree of cleanliness can be maintained without the constant application of copious amounts of water, and with the use of steam for heating purposes modern vessels are much dryer than formerly, and consequently more healthful.

The interior of iron ships is apt to be damp on account of the condensation of moisture on the sides of the vessels. The prevention of the condensation of moisture is sought through the application of paint containing small particles of cork, or a cork lining. The use of wood in modern warships has been avoided as much as possible for two reasons: First, the danger from fire; and second, the disastrous effects from splintering of the wood by perforating shot. The first objection to the use of wood is efficiently removed by the use of fire-proofing materials which have lately come into use, but the second objection remains.

Water-supply.—Great care should be exercised in taking on board a supply of pure and wholesome water for culinary purposes. In the event of a pure water-

supply being unavailable, the necessary apparatus should be on board for sterilizing the water or for distilling sea water. Water-closets and bath-rooms should be installed in different parts of the ship, so as to be conveniently accessible.

Food-supply.—In the case of ships of commerce it is comparatively easy to maintain a fairly satisfactory supply of food. In the case of war vessels the State supplies prescribed rations, which, however, can be supplemented, if necessary, by additional purchases when beyond the base of supplies. Moreover, modern war vessels are equipped with refrigerator appliances, so that fresh meat and vegetables may be carried long distances.

The following is the daily ration supplied to United States marines, based upon the amounts supplied weekly :

Biscuit, cornmeal or oatmeal	454	grams.
Fresh meat, or	567	"
Tinned meat, or	454	"
Salted beef or pork	340	"
Peas, beans, or tomatoes, or	227	"
Fresh vegetables, or	567	"
Canned vegetables	170	"
Butter	24	"
Coffee, or	57	"
Tea, or	14	"
Cocoa	57	"
Pickles	32	"
Syrup	16	"
Vinegar	32	"

The diet should be regulated so as to avoid undue monotony. The harmful influences of excessive amounts of salted meat should be overcome by the use of refrigerated or preserved meats and the use of sufficient amounts of vegetables and fruit. Besides guarding against the use of improper proportions of certain food elements at all times, it is necessary to adapt the dietary to the climate as well as to the nature of the work done by the men. The diet should at all times be sufficient to nourish properly the men under whatever external conditions they may be placed.

Table showing Means for Annual Periods, and for Each Year.

Ages.	Weight.		Height.		Circumference of chest.		Expansion.		Strength.		Vital Capacity.			
											Gihon.		Hutchinson.	
	Pounds.	Kg.	Inches.	Cm.	Inches.	Cm.	Inches.	Cm.	Pounds lifted.	Kg. lifted.	Cu. in.	Liters.	Cu. in.	Liters.
From 13 to 14 years . .	83.5	37.8	57.8	146.7	27.8	70.5	2.5	6.3	155	70.2	157	2.57	160	2.62
At 14 years	85.6	38.7	59.6	151.3	28.2	71.5	2.5	6.3	169	76.5	157	2.57		
From 14 to 15 years . .	95.9	43.4	61.1	155.1	29.0	73.6	2.3	5.6	188	85.1	186	3.04	182	2.98
At 15 years	99.7	45.1	62.3	158.1	29.5	74.9	2.4	5.8	195	88.3	172	2.81		
From 15 to 16 years . .	106.4	48.0	63.9	162.2	30.3	76.9	2.5	6.3	203	91.9	197	3.23	198	3.24
At 16 years	111.9	50.6	64.6	164.0	30.9	78.4	2.5	6.3	214	96.9	203	3.32		
From 16 to 17 years . .	116.2	52.5	65.4	166.0	31.5	80 9	2.6	6.6	220	99.6	210	3.44	214	3.50
At 17 years	117.3	43.1	65.6	166.5	31.8	81.7	2.7	6.8	230	104.1	214	3.50		
From 17 to 18 years . .	123.0	55.7	66.4	168.5	32.3	82.0	2.8	7.1	236	104.4	219	3.58	222	3.63
At 18 years	128.2	58.0	66.8	169.6	32.8	83.2	2.9	7.3	246	111.4	224	3.67		
From 18 to 19 years . .	130.1	58.9	66.9	169.8	33.1	84.0	3.1	7.8	239	104.5	227	3.71	226	3.70
At 19 years	134.0	60.7	67.3	170.8	33.4	84.8	3.1	7.8	248	112.3	234	3.83		
From 19 to 20 years . .	133.3	60.3	67.3	170.8	33.4	84.8	3.1	7.8	256	115.9	230	3.76	230	3.76
At 20 years	134.1	60.7	67.4	171.1	34.4	84.8	3.0	7.6	275	124.5	234	3.83		
From 20 to 21 years . .	135.7	61.4	67.4	171.1	33.8	85.8	3.1	7.8	276	125.0	236	3.84	230	3.76
At 21 years	135.4	61.3	67.4	171.1	33.8	85.8	3.0	7.6	278	125.9	233	3.81		
From 21 to 22 years . .	135.3	61.2	67.4	171.1	33.9	86.0	3.0	7.6	279	126.3	239	3.91	230	3.76
At 22 years	134.7	61.0	67.3	170.8	33.8	85.8	3.1	7.8	279	126.3	234	3.83		
From 22 to 23 years . .	136.9	62.0	67.6	171.8	34.0	86.3	3.2	8.1	265	120.0	242	3.96	234	3.83
At 23 years	136.2	61.6	67.5	171.6	33.6	84.5	3.5	8.8	276	125.0	237	3.88		
From 23 to 27 years . .	139.0	62.9	67.8	172.3	34.5	87.0	3.5	8.8	252	114.1	244	3.99	234	3.83

Dr. Henry G. Beyer[1] calculates that the regular naval ration affords daily 142 gm. nitrogenous matter, 51 gm. fats, and 398 gm. carbohydrates.

Clothing.—The clothing of marines is adapted to the climate of the locality and the season of the year. During hot weather white duck uniforms are worn, while in cold weather woollen clothes and underclothes are supplied. In the navy the question of clothing does not require the same degree of attention and forethought as is often the case in the army, because each individual sailor is not required to carry his wardrobe on his back wherever he goes.

Selection of Marines.—In the selection of marines the same careful physical examination is necessary as in the selection of recruits for the army. This physical examination is directed to the determination of the age, height, weight, chest measurement, sight, and hearing of the applicant. As the result of the careful physical examination of the nude bodies of 6129 lads applying for admission to the U. S. Naval Academy at Annapolis, Dr. Gihon found the following means at different ages (see page 330):

Dr. Gihon concludes that at every age there is a latitude of from 22.5 to 27 kilograms in weight, 17.7 to 21.8 centimeters in height, and 15.2 to 17.7 centimeters in circumference of chest, within which over 900 of every 1000 adolescents will be found, and "it must be recognized as a fact that perfect health and bodily vigor, and the development peculiar to the type and temperament of the individual, are not inconsistent with an average departure below the mean of 12 kilograms in weight, 10 centimeters in height, and 7.5 centimeters in circumference of chest."

Enlistment of boys in the U. S. naval service is made under the following regulations:

"1. Boys between the ages of fifteen and seventeen years may, with the consent of their parents or guardians,

[1] *Proceedings U. S. Naval Institute*, p. 609, 1899.

be enlisted to serve in the navy until they shall arrive at the age of twenty-one years.

"2. No minor under the age of fifteen years, no insane or intoxicated person, and no deserter from the naval or military service of the United States, can be enlisted.

"3. Boys enlisted for the naval service must be of robust frame, intelligent, of perfectly sound and healthy constitution, and free from any of the following defects:

"Greatly retarded development; feeble constitution, inherited or acquired; permanently impaired general health; decided cachexia, diathesis, or predisposition; weak or disordered intellect; epilepsy, or other convulsions within five years; impaired vision or chronic disease of the organs of vision; great dulness of hearing or chronic disease of the ears; chronic nasal catarrh; ozena, polypi or great enlargement of the tonsils; marked impediment of speech; decided indications of liability to pulmonary disease; chronic cardiac affections; hernia or retention of testes in inguinal cavity; circocele, hydrocele, stricture, fistula, or hemorrhoids; large varicose veins of lower limbs, scrotum, or cörd; chronic ulcers; cutaneous and communicable diseases; unnatural curvature of the spine, torticollis or other deformity; permanent disability of either of the extremities or articulations from any cause; defective teeth; the loss or extensive caries of four molar teeth.

"4. Physical examinations will be made by the medical officer of the ship upon which a boy presents himself for enlistment.

"5. Boys must have the following heights and measurements:

Age.	Height not less than—	Weight not less than—	Chest measurement, breathing naturally, not less than—
Fifteen years . .	4 feet 11 inches.	80 pounds.	27 inches.
Sixteen years . .	5 feet 1 inch.	90 pounds.	28 inches.

"6. They must be able to read and write.

"7. In special cases, where a boy shows general intelligence, and is otherwise qualified, he may be enlisted notwithstanding his reading and writing are imperfect.

"8. Each boy presenting himself for enlistment must be accompanied by his father, or by his mother in case the father be deceased, or by his legally appointed guardian in case he has neither father nor mother living, and the parent or guardian presenting the boy must sign the prescribed 'Consent, declaration, and oath,' which forms part of the shipping articles.

"9. In cases where parents or guardians may, by reason of distance, infirmity, or other causes, be unable to appear at the place of enlistment, they will, on written application to the commanding officer of either of the ships upon which enlistments are made, be furnished with the printed form of 'Consent, declaration, and oath,' in duplicate, by executing which the enlistments will be perfected, should the boys be accepted by the board of examining officers."

"On first enlistment men must be between the following ages:

Rating.	Years of age.	Rating.	Years of age.
Seamen	21 to 35	Firemen, second class	21 to 35
Ordinary seamen	18 " 30	Coal-passers	21 " 35
Landsmen	18 " 25	Hospital stewards	21 " 30
Shipwrights	21 " 35	Hospital apprentices, 1st class	18 " 25
Blacksmiths	21 " 35	Hospital apprentices, 2d class	18 " 25
Plumbers and fitters	21 " 35	Officers' stewards	21 " 35
Sailmakers' mates	21 " 35	Officers' cooks	21 " 35
Machinists, first class	21 " 35	Mess attendants	18 " 30
Machinists, second class	21 " 35	Ships' cooks, fourth class	18 " 30
Electricians, third class	21 " 35	Musicians, first class	21 " 35
Boilermakers	21 " 35	Musicians, second class	21 " 35
Coppersmiths	21 " 35	Buglers	21 " 35
Firemen, first class	21 " 35	Painters	21 " 35

"Minimum height for ratings herein mentioned, 5 feet and 4 inches, stripped; the candidate should be well developed, considering his age and height.

"Persons possessing a mechanical trade may be enlisted even if over twenty-five, provided they are under thirty-five years of age.

"No person, except an honorably discharged ex-appren-

tice, shall be enlisted as a seaman unless he shall have been four years at sea, nor as an ordinary seaman unless he shall have been two years at sea before the mast. In both cases applicants shall be required to pass a satisfactory examination."

The general appearance of the applicant is also taken into consideration, and those that are uncleanly in their person or attire are discarded because they prove incapable of efficient training.

Recently the character of the teeth in applicants for both the naval and military service has been taken into consideration. It is evident that a man whose grinding and biting capacity is seriously impaired will more readily suffer from gastro-intestinal trouble than one with a full set of perfect teeth. The loss of five teeth, absent or unsound in any degree, is usually considered as cause for rejection ; even the loss of three or four molars or incisors in the same jaw is sufficient to render a young man unfit for service in the navy.

Principal Diseases among Mariners.—The average strength of the active list of the U. S. Navy for the year 1899 was 20,019. The total number of admissions for disease was 12,794, and for injuries 2955, giving a ratio per 1000 of strength of 636.11 and 146.92, respectively. During the year there were admitted to the sick list, of the total force—

Malarial diseases	943 cases.	Pneumonia	117 cases.
Diarrheal affections	900 "	Pulmonary tuberculosis	87 "
Wounds	884 "	Dysentery	68 "
Rheumatic affections	716 "	Organic heart-disease	42 "
Bronchial affections	685 "	Measles	37 "
Epidemic catarrh	672 "	Nephritis	31 "
Dengue	297 "	Scarlet fever	29 "
Alcoholism	193 "	Yellow fever	8 "
Heat-stroke	154 "	Small-pox	6 "
Typhoid fever	134 "		

Of the 943 cases of malarial diseases, nearly one-third were from the navy-yard and marine headquarters, Wash-

ington, D. C.; of the 134 cases of typhoid fever reported during the year, 49 were under treatment in the naval hospital, Newport, R. I. Of this number, 45 originated among the *personnel* of the training station, 1 was received from the torpedo station, and 3 from ships of the North Atlantic squadron.

During the year 1918 there were 9307 deaths. Of these, 5938 were due to disease, 1158 to accidents and injuries, and 2211 to casualties in action. Of the 5938 deaths from disease, 5027 were due to pneumonia in one form or another, as follows:

Lobar pneumonia	601
Bronchopneumonia	156
Influenza pneumonia	4158
Measles pneumonia	112
Total	5027

If pneumonia in its various forms could have been eliminated as a cause of death, the death-rate in the Navy for disease would have been only 1.80 per 1000. Excluding influenza as a cause of death, the death-rate would have been but 3.53 instead of 11.78.

CHAPTER XV.

SOIL.

THE nature of the soil in its relation to health is an important subject. The relation of the soil of a locality to the public health is dependent upon its intimate structure. Soils are composed of varying proportions of mineral, vegetable, and animal constituents. These constituents vary in size not only in different localities, but even in the same locality. The interstices of the soil are filled either with air or with water. A soil is moist or dry according to the preponderance of small- or large-sized soil-particles. The finer and more uniform the soil-particles, the greater the amount of moisture usually contained in the soil.

All soils are porous, and contain varying amounts of air and moisture. The relation of the soil to health is influenced by the amount and nature of the contained air and water. The degree of purity of the ground-air and ground-water is influenced by the amount and nature of the vegetable and animal organic matter contained in the soil, and the temperature of the locality—whether favorable or unfavorable to the decomposition of organic matter through the agency of bacteria.

Ground-air.—Ground-air is usually rich in carbon dioxid, derived from decomposing organic matter in the soil. It is also very moist, because there is usually plenty of opportunity to take up moisture. It also contains decomposition-products, such as marsh-gas, hydrogen sulphid, and ammonia. This air is, consequently, not suitable for respiratory purposes. The amount of soil-air that gains access to houses under ordinary conditions is, however, so small that its influence probably is not felt. In newly made soils, in which there is considerable decaying organic matter, there is some

danger of the entrance of large amounts of ground-air into houses built on such soils unless special provision is made to exclude it. In such houses there should be cemented foundation walls and cellars, and the supply of fresh air should be derived from the outside at some distance above the ground. Unless the foundation walls and cellars are cemented, the houses, when warmed, may serve as immense chimneys in extracting the air from the surrounding soil.

Ground-water.—Ground-water is rain-water that has fallen upon the soil of the locality and penetrated its surface. It differs from stored rain-water according to the nature of the soil constituents. It is richer in dissolved solids, and contains also the products of decomposition derived from decaying organic matter in the soil. It contains also numerous bacteria derived from the soil. The relation of ground-water to health is directly dependent upon the presence or absence of pathogenic bacteria in the soil, and the presence or absence of mineral constituents derived from the soil which may be injurious to health, such as salts of calcium, magnesium, or iron in large amounts.

Pettenkofer's theory of the relation of soil moisture to typhoid fever and cholera is no longer tenable. We know now that the height of the level of the ground-water has no direct influence in the production of either of these two diseases. There is evidently an indirect relation between low ground-water and the development of these diseases, because at such times the drainage area of all wells is increased, and the polluting material in or upon the soil of a correspondingly greater area is conducted into the well. In the same manner, when drinking-water is derived from streams, there is greater opportunity for the entrance of concentrated polluting matter into the stream, and it exists there in a more concentrated form than in times of flood.

The relation of a damp soil to the greater prevalence of consumption, as originally pointed out by Bowditch, cannot be regarded as a direct one. The damp soil prob-

ably predisposes to colds and diseases of the lungs, and thus paves the way for the contraction of consumption. There is thus far no evidence that the bacillus of tuberculosis is capable of multiplying in damp soils.

The relation of damp, marshy soils to malaria has received a great deal of elucidation in recent years. It is believed at the present time that the malarial organism is contracted most frequently, if not entirely, through the sting of a particular genus of mosquito—Anopheles. These mosquitoes are usually indigenous to the soil of certain marshy localities, but thus far no definite relation between the nature of the soil of these localities and the prevalence of mosquitoes has been demonstrated. Marshy localities, when drained so as to prevent the development of mosquitoes, also become healthful and free from malaria. Where drainage is impossible, it is known that the application of some oil, such as crude petroleum, on the surface of the water will prevent the development of the mosquitoes and thus eradicate malaria from those localities.[1]

Damp soils are likely to be productive of diarrheal diseases, though these affections are most probably brought about by certain bacteria in the soil along with the detrimental influence of the dampness itself. The amount of decaying organic matter in and upon the soil is most probably in direct relation to the prevalence of diarrheal diseases in a locality.

In the same manner the amount of moisture in the soil will influence the prevalence of other diseases, such as rheumatism, bronchitis, pneumonia, and the exanthemata. The relation of soil moisture to these diseases is probably only an indirect one, in that it tends to lower the general vitality of the individuals living in the locality.

Pathogenic Bacteria in Soil.—Some of the pathogenic bacteria are apparently capable of living in the soil for a long time, and some of them may even be able to multiply in the soil. Among these, Bacillus anthracis,

[1] Recent studies indicate that probably other diseases, especially yellow fever, dengue, and filariasis, are conveyed by species of mosquitoes.

Clostridium tetani, Clostridium welchii, and Clostridium edematis are perhaps most capable of subsisting in the soil because of their faculty of passing into the spore stage.

Bacterium typhosum and the cholera organism are less tenacious, and die after a time through the detrimental influence of the soil organisms. Bacillus tuberculosis can remain alive in soil for some time when protected from the influence of soil organisms, though the danger of infection through polluted soil is probably a remote one. The pyogenic cocci and the diphtheria bacillus cannot exist in the soil for any length of time unless protected from the influence of the soil organisms.

Improvement of a Damp Soil.—A damp soil may be improved by opening the outflow or by laying a system of underground drains. The construction of sewers often serves to drain the soil to a considerable extent because the ground-water follows the outside of the sewer.

Configuration of the Surface and Soil-covering.—Aside from the intrinsic nature of the soil itself, and the character and amount of air and water contained in its interstices, the healthfulness of a soil is influenced also by the configuration of the surface, the condition of the surface, and the nature of the soil-covering. With regard to the configuration of the surface, it may be said that, as a rule, highlands are more healthful than lowlands. The degree of healthfulness of lowlands is influenced by the nature of the soil composing them. The condition of the surface of the soil with regard to soil-covering which is least healthful is what is known as a desert. Here the soil is exceedingly dry and cannot be cultivated. Cultivated areas and areas covered with forests are more healthful, because the soil is shaded and thus the heating effect of the sun's rays is partly excluded. Cultivated areas that are thickly populated are less healthful because of the organic impurities which gain access to the soil. The soil of cities can be maintained in a comparatively healthful condition only by systematic drainage, so as to carry away all the organic impurities without contaminating the soil, air, or drinking-water.

CHAPTER XVI.

HABITATIONS.

THE first consideration in the selection of a site for a habitation is the nature of the soil with regard to dampness and organic impurity, since these are the principal factors in rendering a soil unhealthful. The house should stand upon a site the subsoil of which is naturally dry, or is properly drained and free from impurity. The configuration of the surface, the elevation, and the exposure are important features in rendering the locality favorable for a healthy habitation. The nature, source, and amount of the water-supply should be investigated. The possibility for the economic and safe disposal of all refuse matter must also be considered. The locality should be sufficiently elevated to secure good drainage away from the house. A southern exposure is preferable, especially in colder climates. The proximity of large bodies of water and of marshy areas have detrimental influences upon the healthfulness of the locality.

The habitation should be so situated with relation to others surrounding it that an abundant supply of fresh air and sunlight can be secured. The healthful influences of sunlight and fresh air cannot be ignored. The absence of sunlight and deficiency of fresh air are the most important factors in inducing disease in the homes of the poorer classes in our large cities.

Position of the House.—If possible, the house, especially when located on open ground, should face the south or west, in order to secure the greatest amount of sunlight in that portion of the house most constantly occupied. The windows require protection with blinds and awnings in summer, to exclude the heat and glaring

effect of the sun; but in winter the full and free action of sunlight should be secured, at least during a part of each day, because of its purifying influence upon the air of the house.

Foundation and Walls.—The foundations and walls should be as dry as possible, and in damp soils this can be secured only by draining the subsoil below the foundations, and by cementing the foundation walls and cellar floor. If there is no cellar, the floors should be raised about 0.5 meter above the ground, so as to secure thorough ventilation beneath the floor. Dryness of the walls

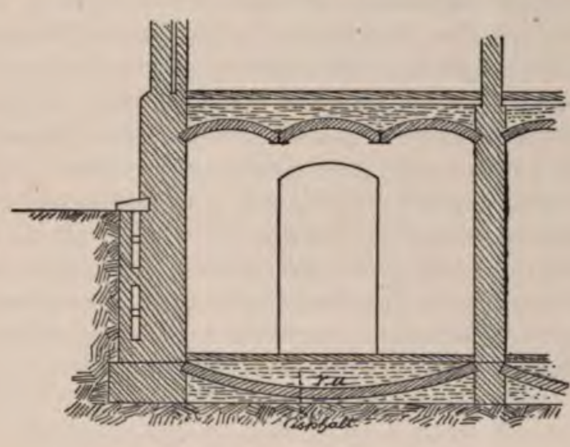


FIG. 57.—Double foundation walls.

is best secured by means of hollow walls (Fig. 57), or by coating the walls with cement or slate. Bricks are quite porous and absorb a great deal of moisture, and thus render the walls damp. Stone also is porous and retains moisture for a long time, consequently stone houses are liable to be damp.

The Roof.—The roof of the house must be carefully constructed and frequently examined in order to prevent leaking. The material composing the roof is of no vital importance so long as it excludes rain. The rain-water falling upon the roof should be conducted away from the

house, so as to prevent the soil of the locality from becoming unduly damp from this cause.

The Interior Arrangement.—The interior of the house should be arranged so as to afford the greatest facility for the use of every part of it for the purposes for which it is intended. The stairways should be wide and the steps broad, with easy slope, so as to prevent fatigue as much as possible in going from one floor to another. The rooms on each floor should communicate with each other, or with a common hallway, so as to favor easy access and insure more efficient ventilation.

Size of the Rooms.—The size of the rooms is a matter of the greatest importance in maintaining the purity of the contained air. The detrimental influence of insufficient air space is well known. The point of greatest hygienic importance is not *how many rooms* a person has, but *how much room*. A small room may be overcrowded with a single person in it, while a large room is not overcrowded with four to six persons in it. Aside from the matter of cubic space, the question of the dimensions of the room is of the greatest importance. The minimum amount of cubic space allowable in sleeping-rooms per adult person is 25 cubic meters. It is evident that a room 3 meters high is far more easily ventilated than one that is 10 meters high with the same amount of air space. Sleeping-rooms should be at least 2.75 meters high, though a height much in excess of 3 meters is not desirable. A room less than 2 meters in height is not suitable for a sleeping-room. The floor space of a sleeping-room should be at least 8 square meters. The living-rooms of a house should possess a cubic space of about 30 cubic meters.

If the arrangements for ventilation are efficient, the air will require to be changed about three times an hour in a room of 25 to 30 cubic meters capacity, while in a room of only 10 to 12 cubic meters the air must be changed seven to eight times an hour in order to maintain its purity. The living-rooms of a house should be

correspondingly larger than the sleeping-rooms, in order to accommodate the larger number of persons occupying them, and the greater amount of exhalation from the body, and the greater amount of impurity derived from heating and lighting. It has been estimated that every lighted gas-burner requires from 300 to 400 cubic meters of fresh air per hour in order to prevent an undue amount of pollution of the air of a room from this source, and to maintain the standard of purity.

The Sleeping-rooms.—Lawson Tait, on the basis of a lifelong experience and observation, stated that the bedroom should have a capacity of 56 cubic meters, with tight-fitting doors and windows, and a ventilating flue of at least 1.5 decimeters in diameter. The window-panes should be of plate glass to prevent the too rapid cooling of the air of the room. He advised the construction of houses with double walls, with an air space between them of at least 0.75 decimeter, in order to prevent dampness of the walls. If possible, the room should be warmed with gas, as this is the best method of maintaining a uniform temperature. He directed that the bedstead shall be of steel or iron, 2 meters in length, and of a width sufficient to accommodate only one person. Two such bedsteads should be placed side by side. The danger of communicating such a disease as consumption from one person to another while sleeping together is quite evident. The healthfulness of single beds is generally recognized, though in America, as in England, they are not in very common use.

Since we have learned the great value of the open-air treatment of tuberculosis and other diseases, the advisability of spending more of our time in the open air has been apparent, and physicians are advising their patients to sleep with windows open all the year. Where the rooms are heated during the day one may prepare for bed in a warm room and open the windows on retiring. In this way the bedclothes are kept warm and dry, and there is no danger in sleeping with the windows wide

open as long as the sleeper is protected against the cold blasts of the wind. It is necessary to guard against direct draughts and to supply abundant bed-clothes. Under these conditions sleep is far more sound and refreshing, and the body maintains its vigorous state under greater stress than otherwise.

The Floors and Floor-coverings.—Hard-wood floors are to be preferred, because they are less pervious to dust and therefore more easily kept in a sanitary condition.

The covering of the floors of a house has an important influence upon its healthfulness. Carpets and matting are objectionable, because they are fastened to the floor and are allowed to remain in place for months or even years. It is preferable to have the floors painted and covered with a rug that can be removed, aired, and cleaned at frequent intervals.

The Wall-covering.—The covering of the walls of rooms is a matter of the greatest importance. Wall-paper or paint of a bright-green or red color should be avoided, because these colors may contain arsenic. The arsenic in wall-papers will eventually become detached and be present in the air of the room as arsenical vapor. Sufficient arsenic has been found in the air of rooms, derived from these sources, to produce poisonous effects in those constantly breathing the air. The custom of placing a new layer of wall-paper on the old and soiled paper cannot be condemned too vigorously. This custom is very generally practised in spite of repeated remonstrances and warnings of the danger involved. All the filth contained on the old paper is allowed to remain on the walls, and is simply covered over with another layer of paper. This goes on until the number of layers of paper is so great that its weight prevents it from adhering to the walls any longer. Whenever a room needs papering, the old paper should be carefully removed and the walls scraped before a layer of new paper is placed upon them.

The prevalence of tuberculosis in certain houses year after year and generation after generation can be traced, at least in considerable part, to the custom of repapering the walls without previously removing the soiled paper, as well as to neglect of disinfection and cleansing after death or removal of a case of tuberculosis. This condition will continue until compulsory registration of all tubercular patients is secured. The tubercle bacillus is capable of existing in the dust of rooms for a long time, and the inhalation of this infectious dust by susceptible persons is no doubt a frequent source of infection. When moving into an old house, therefore, it will be safest to give it a thorough cleansing and disinfection, to prevent the contraction of disease from infected dust and the soiled walls and woodwork of the house.

It is preferable to have the walls painted, in order that they may be cleaned and disinfected without injury. Where the delicate nature of the wall paint does not permit efficient cleansing and disinfection a fresh coat of paint should be applied instead. This will serve to disinfect the walls in an efficient manner.

Ventilation and Heating.—When a general system of heating and ventilation is employed, by means of a furnace or indirect heating with steam, provision should be made for securing pure, fresh outside air. The more or less stagnant air of the cellar should not be employed for this purpose. Ventilating flues of appropriate size should lead to each of the rooms, so that the ventilation of each may be independent of every other part of the house. Provision must also be made for the escape of the impure air from each room, a matter which is very frequently neglected.

When the rooms are warmed by direct heating of some form or another it is still necessary to provide for the entrance of fresh air. In such a system of heating the outside air cannot always be brought in at the desired temperature, and it becomes necessary to provide special devices for bringing in the fresh air without creating

draught. The fresh air cannot be brought in by simply opening the windows without creating draughts. The simplest method is by placing a board underneath the lower sash, so as to allow the air to enter between the lower and upper sash (see Fig. 8). In this way the incoming air will continue its upward course and become distributed through the upper portion of the room. A number of devices have been invented to bring about the same results without the use of a board beneath the lower sash, among which are perforated window-panes, and an upper sash that slopes inward. Fresh air may also be admitted through special openings in the walls, but in this method it is necessary to conduct the incoming air upward toward the ceiling, so as to avoid draught. The inlet openings should always be high enough to prevent the current of air impinging on the occupants of the room. In order to secure efficient ventilation where the system of indirect heating is employed, it is necessary to provide exit openings for the impure air in the room.

Cooling Devices.—During the summer months it is frequently desirable to cool the air of a room or of the entire house. For the purpose of cooling the air of a single room small electric fans are in very general use. These serve to propel the air through the room at a high rate of speed, and thus produce a cooling effect through the greater evaporation from the surface of the body. Recent experiments on human beings, confined in a special chamber, demonstrate that when the air is in a highly vitiated state through the accumulation of the products of respiration, the setting up of active movements in the air with an electric fan will at once relieve the oppression of the occupants.

The air of an entire house may be cooled by passing it through a chamber filled with ice, the air being propelled throughout the different parts of the house by a large fan or blower. This method is, however, very expensive, as it requires large quantities of ice or the employment of an ice machine of one or more tons daily

capacity, according to the size of the house to be cooled and the initial temperature of the outside air. Passing the incoming air through a large screen, over which a spray of ice-water is falling, will also serve to cool the air.

Liquid air has been employed as a means of cooling the air of theaters in summer and has proved satisfactory, although this is also an expensive method. Within recent years Professor Gates, of Washington, devised an

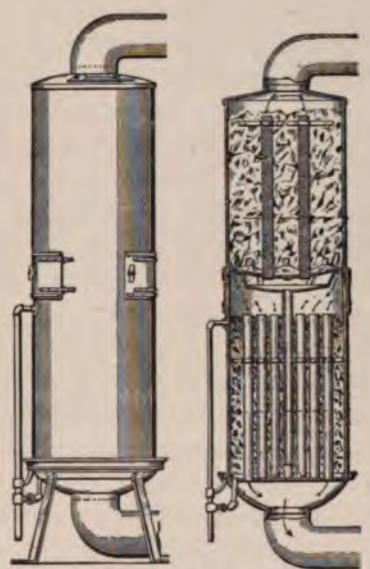


FIG. 58.—The Nevo. Front and sectional views.

apparatus for cooling the air which, it is claimed, can be operated more cheaply than a stove. Professor Willis L. Moore, of the United States Weather Bureau, has also devised an apparatus for this purpose called the "Nevo" (Fig. 58). This apparatus consists of a cylinder containing compartments filled with cracked ice and salt, through which the warm air descends. The cool air issues at the bottom, and from this point gradually mingles with the air of the room. The higher the outside temperature,

the greater the volume of air which passes through the apparatus. Different sizes of this apparatus adapted for use in single rooms or larger apartments are now on the market.

Plumbing and Drainage.—The character of the plumbing and drainage of urban houses has a direct influence upon the health of the occupants. All the appliances, such as sinks, water-closets, and bath-tubs, should be supplied with appropriate traps, in order to exclude the drain-air. These traps are now generally required by the sanitary laws of all large municipalities, and the form and character of the traps to be employed are frequently stated in these laws. While the danger from sewer-air spoken of in the older text-books is greatly exaggerated, it is well known that such air must be rigidly excluded from houses to avoid any possible injurious effects. Continued breathing of air containing the considerable quantities of carbon dioxid found in sewer-air, besides the other putrefactive gases present in it, will eventually prove injurious.

The plumbing should serve to bring into the house an abundant supply of water and distribute it to all parts for convenient use. The drainage system should be so constructed as to remove promptly and safely all sewage and waste water from the house.

Houses for the Poor.—The overcrowded condition and unhealthful character of the habitations of the poor have called forth special regulations governing this matter in many large cities. The causes which have led to overcrowding are numerous, the principal being (1) the necessity of living near their work, (2) the high price of land arising from the same fact, (3) the higher taxes and rents resulting from the same conditions, and (4) limited means, which prevent them from living under better conditions.

In recent years this condition of overcrowding has been greatly diminished through the influence of several factors, such as (1) the employment of electricity as a

motive power for street railways. By this means the cost of travelling has been diminished, the speed of the cars has been increased, and the lines of travel have been extended into the suburbs of cities, where cheaper and more healthful houses can be procured. (2) The destruction by the municipal authorities of the more objectionable of the overcrowded tenements. (3) The regulation of the size, construction, and arrangement of all new dwellings through legislation. One of the most efficient ways of preventing overcrowding is to be sought in affording better communication between the periphery and center of a city, so that those working in the city are not compelled to live there, but make it possible for them to live in the suburbs.

According to the investigations of J. Bertillon,[1] the population of Paris is distributed in the following manner: 149 per 1000 live in overcrowded dwellings, 363 per 1000 have insufficient room, 266 per 1000 have sufficient room, and 222 per 1000 have more than sufficient room.

According to the same authority, the proportion of population living in overcrowded dwellings in the larger European cities is as follows:

280	per 1000	of the	Berlin	population.
200	"	"	London	"
310	"	"	Moskow	"
460	"	"	St. Petersburg	"
740	"	"	Budapest	"

Of the Paris population, 378 per 1000 have 2 persons per family, 687 per 1000 have 4 persons per family, 753 per 1000 have 7 persons per family, and 295,000 out of 947,000 families consist of only 1 person; and 369,000 out of 942,000 dwellings have 1 room.

Municipal legislation regulating the construction of workingmen's homes should prescribe the size of the rooms, the number of square meters of floor space for

[1] *Rev. d' Hyg.*, vol. xxi., p. 588.

each occupant, and the amount of window surface in relation to the floor surface. The regulations should also direct the character of the drainage facilities that are to be supplied.

In many European cities the construction of new houses is so regulated as to prohibit the utilization of more than a definite proportion of the ground surface for building purposes. This feature prevents the construction of houses in too close proximity to adjoining houses. In many of these regulations the height of the houses is regulated by the width of the streets on which they front, or the section of the city in which they are located. For instance, in Bonn, a city with 50,000 inhabitants, the smallest size of the yards in the business section is 25 per cent. of the ground surface for buildings one story in height, and 35 per cent. for buildings more than one story in height, and the greatest height allowed is 20 meters. In the residence portion of the city the smallest size of the yards is 25 per cent. for houses of one story in height, and 50 per cent. for houses of more than one story in height, and the greatest height allowed is 17 meters.

Building regulations should also include the requirements of lodging- and boarding-houses, because it is in these that a great degree of overcrowding is found. These regulations should state the amount of cubic space that must be allowed for each lodger, according to age, and the arrangements for the efficient ventilation of the rooms that are necessary to secure a continuous supply of pure air. These regulations should also provide for the general sanitary supervision of the premises and arrangements by competent inspectors.

House-cleaning.—From the fact that living bacteria may be contained in the dust of rooms the method of house cleaning is of importance. Great care should be exercised to avoid disseminating collections of dust on horizontal surfaces. All the furniture, woodwork, and painted walls should be wiped carefully with a dampened

cloth, in order to remove the dust without causing it to rise into the air of the room.

The vacuum cleaner makes house-cleaning less of a drudgery than formerly, and at the same time permits the cleaning to be accomplished without raising volumes of dust, as is done by sweeping. Where the house is wired for electric lighting it is possible to use light, portable vacuum cleaners, which clean floors and floor coverings, walls, and furniture in an efficient and sanitary manner.

The rugs on the floor should be removed from time to time and thoroughly dried and cleaned. The floors should be waxed and polished before replacing the rugs. Special preparations have been perfected for this purpose. These are applied by means of a long-handled brush and then rubbed into the floor by means of a large burnisher. Some of these floor preparations contain turpentine, or other antiseptic substances, and serve a useful purpose in addition to preserving the quality of the floor.

Protection from Flies and Mosquitoes.—Since flies are frequent carriers of disease, they should be rigidly excluded from the house. Flies feed on filth, and in this manner their bodies may become soiled with pathogenic bacteria, and they no doubt carry these bacteria from place to place and contaminate whatever they light upon. During the Spanish-American War the spreading of typhoid fever from one portion of a camp to another was probably in part due to this mode of dissemination of the typhoid bacillus. During the summer months, therefore, all the doors and windows should be fitted with efficient mosquito-bars, in order to exclude flies and mosquitoes. The experiences of the several commissions which have been sent to malarious localities in Africa, Italy, and India have demonstrated the fact that simply excluding mosquitoes from habitations by means of mosquito-bars serves to protect the occupants against malarial infection.

CHAPTER XVII.

VITAL CAUSES OF DISEASE.

THE vital causes of disease are those vegetable and animal organisms which are capable of existing as parasites in or upon the human host, and by their mere presence, or through the production of poisonous products, cause disease. The vegetable organisms producing disease are of two classes—the bacteria, and various fungi which produce local affections of the skin. Fortunately, only a small proportion of the bacteria found in nature are pathogenic. A number of the specific diseases, however, have been traced to the activity of these organisms. All of these pathogenic organisms are transmissible from one individual to another if not already immune. One attack of certain of these specific diseases confers immunity against subsequent infection from the same species of organism. In some instances this immunity is permanent, lasting throughout life, while in other diseases it is of short duration, lasting only a few weeks or months. The specific organisms of each disease differ in their morphologic and biologic characters from those causing other diseases to such an extent that they can be recognized and isolated.

The micro-organisms which are pathogenic for man, and the specific organisms of the following diseases, have been discovered and isolated, as follows:

1839, parasite of favus;
1863, bacillus of anthrax—Davaine;
1873, spirochæte of relapsing fever—Obermeier;
1875, bacillus of malignant œdema—Pasteur;
1878, actinomyces bovis—Bollinger;
1879, micrococcus of gonorrhea—Neisser;
1880, plasmodium malariæ—Laveran;
1880, micrococcus lanceolatus (pneumonia)—Sternberg;

1880, bacillus of typhoid fever—Eberth;
1881, micrococcus tetragenus—Koch and Gaffky;
1882, bacillus pyocyaneus—Gessard;
1882, bacillus of tuberculosis—Koch;
1882, bacillus of glanders—Löffler and Schütz;
1882, bacillus of rhinoscleroma—von Fisch;
1883, streptococcus pyogenes—Fehleisen;
1883, bacillus lanceolatus—Friedländer and Frobenius;
1884, vibrio of Asiatic cholera—Koch;
1884, staphylococcus aureus and albus—Rosenbach;
1884, bacillus of diphtheria—Klebs and Löffler;
1884, bacillus of tetanus—Nicolaier;
1885, staphylococcus citreus—Passet;
1885, proteus vulgaris—Hauser;
1886, bacterium coli—Escherich;
1886, bacterium aërogenes—Escherich;
1887, micrococcus intracellularis—Weichselbaum;
1889, bacillus capsulatus—Pfeiffer;
1889, bacillus of chancroid—Ducrey;
1892, clostridium welchii—Welch;
1892, bacillus of influenza—Pfeiffer;
1894, bacillus of bubonic plague—Yersin and Kitasato;
1894, bacillus of infectious conjunctivitis—Koch-Weeks;
1895, clostridium botulinus—Van Ermengem;
1897, clostridium sporogenes—Klein;
1897, micrococcus melitensis—Bruce;
1898, bacterium dysenteriæ—Shiga;
1900, bacillus mortiferus—Harris;
1901, bacterium paratyphosum—Schotmüller;
1902, trypanosoma gambiense—Dutton;
1905, treponema pertenuis—Castellani;
1906, treponema pallidum—Schaudinn and Hoffmann;
1906, spirochæta duttonii—Breinl;
1906, bacillus of whooping-cough—Bordet and Gengou;
1907, spirochæta novyi—Shellack;
1907, spirochæta carteri—Manson;

1914, leptospira icterohæmorrhagiæ—Iviada and Ido; 1917, leptospira hebdomados—Ido, Ito, and Wani; 1918, leptospira icteroides—Noguchi.

In the following diseases no specific organisms have as yet been isolated, though from their clinical manifestations and contagious character they are believed to be due to some specific agent: Varicella, smallpox, measles, scarlet fever, mumps, dengue, typhus fever, and rheumatism. A variety of micro-organisms has been found in most of these diseases, though none of them has been positively demonstrated as specific.

Modes of Dissemination.—Those diseases which are infectious may be disseminated in several different ways. The confusion which is more or less prevalent with regard to the exact term to employ in each disease, whether infectious or contagious, has led numerous writers to abandon one or the other term. Since all contagious diseases are infectious, it seems preferable to abandon both, and to substitute the term transmissible, as has been done by Dr. Abbott,[1] and call those diseases which were formerly designated as contagious, transmissible by direct contact, and those diseases which were formerly designated as infectious, transmissible by indirect contact. Diseases like small-pox, measles, and scarlet fever are transmissible by direct contact; and diseases like typhoid fever are usually transmissible by indirect contact.

Some of the diseases, however, which are frequently disseminated by direct contact may be, and often are, disseminated indirectly through the medium of food infected with the specific micro-organisms, or through the agency of flies or other insects whose bodies have become infected by coming in contact with infective materials. A number of diseases, prominent among which are those due to animal parasites, are disseminated through the use of meat derived from infected animals, through water polluted with animal excrement, or through green vegetables that have come in contact with such excrement.

[1] *The Hygiene of Transmissible Diseases.*

In addition to diseases transmitted by the methods indicated, there are some diseases in which the infective agent passes one of its cycles in the body of an insect, and is disseminated through the bite of such infected insect. The disease which is best known as being disseminated in this manner is malaria, which is disseminated through the bite of infected anopheles, while filariasis is believed to be disseminated through the bite of another mosquito, a species of culex, and the recent studies upon yellow fever show conclusively that this disease is disseminated through the bite of another mosquito—stegomyia fasciata.

In the light of the discoveries in regard to the mode of dissemination of malaria, filariasis, and yellow fever by mosquitoes, and the dissemination of Texas cattle fever, the spotted fever of the Bitter Root Mountains, and African tick fever by ticks, and sleeping sickness by the tsetse fly, it is safe to predict that other diseases will be found to be disseminated by somewhat similar agencies. There is no doubt that in the immediate future the investigations of scientists will be directed toward the discovery of such disseminating agencies, and with the discovery of such agencies the causes of these diseases, as yet undetermined, may likewise be discovered, and our measures of prevention placed upon a more satisfactory basis.

Nature of Epidemics.—The opinions of authorities differ with regard to the number of cases of any infectious disease that may exist in a community before the disease may be declared to be epidemic in its character. A few isolated cases are usually spoken of as an "outbreak" of the disease; but when the number of cases amounts to 1 per 1000 of the population, it is usually said to be epidemic. In England, measles is said to be epidemic when the number of cases amounts to 1.2 per 1000 of the population. Some years ago yellow fever was said to be epidemic when the number of deaths from that disease exceeded the number from all other causes. More recently the disease was considered epidemic in New Orleans when

there were between 2000 and 5000 cases, or about 22 per 1000 of population. Usually when 10 cases of any disease develop in close proximity to each other, when all sanitary precautions have been exercised, the disease is said to be epidemic.

A disease is said to be *epidemic* when the infection has been imported into a locality and spreads over an area. A disease is said to be *endemic* when it develops within a locality, or is peculiar to a locality, and spreads over an area. A disease is said to be *pandemic* when it spreads over very large areas or prevails in several continents at the same time. The term *pandemic disease* is usually applied to cholera, yellow fever, influenza, and plague. The different pandemic diseases have local habitats from which they are rarely or never absent. The habitat of influenza is in Russia, that of cholera in the valley of the Ganges River, that of plague in Indo-China, and that of yellow fever in countries bordering on the Gulf of Mexico and Caribbean Sea.

Immunity and Susceptibility.—When we undertake to investigate the causative factors underlying the results of the exposure of an entire community to a source of infection, with the idea of ascertaining the reasons why a certain proportion of such a community escapes the infection, a number of questions of great practical importance present themselves. We are frequently satisfied in solving these questions by saying that those members of the community which escaped the disease did so from the fact that they were not susceptible, or, probably, that they were immune, and that those who contracted the disease were susceptible, or that they were not immune.

It will be necessary to consider briefly what is meant by the terms susceptibility and immunity, and then we shall better understand why such differences in effects manifest themselves.

Immunity may be described as that condition of the body in which it resists the invasion of disease-producing bacteria, or resists their growth and activity after they

have gained an entrance; while susceptibility is a condition in which, instead of the resistance of the body overcoming the action of the invading parasites, the parasites overcome the resistive forces of the body and disease results.

Immunity is either natural or acquired. Natural immunity is the inherent, vital reaction of a healthy organism against the invasion of disease-producing bacteria. There is greater susceptibility of some races to certain diseases than to others. Also there may be a family resistance transmitted from generation to generation, or it may be individual.

The principal factors upon which natural immunity depends are the following: (1) The normal fluids of the body are germicidal either through the presence of acids or through the presence of bactericidal, agglutinative, opsonic, and antitoxic substances, which can always be detected in the blood in limited amounts. (2) The skin and mucous membranes are so constructed as to prevent the invasion of bacteria. (3) Those bacteria which escape the foregoing defensive agents of the body may be taken up and destroyed by the phagocytes after they have been acted upon by the opsonins.

This natural immunity, in man as well as in animals, is frequently destroyed through external agencies, such as changes in the nature and quantity of the food-supply, changes of modes of living, as from outdoor occupations to indoor occupations, undue exposure, close confinement through lack of sunshine and fresh air, as well as many other changes in the environment which tend to lower the general vitality of the system. By modifications in the activity and environment of the lower animals it is often possible to render them susceptible to the action of certain bacteria which do not affect them normally.

Acquired immunity may be divided into—(*a*) Naturally acquired, that induced by recovery from a previous attack of a disease, as is the case with some of the common diseases of childhood, as rubeola, scarlatina, and varicella. One attack of these diseases usually confers im-

munity for life. That induced by an attack of an allied disease, as in the immunity conferred by vaccinia against variola. (*b*) Artificially acquired, that induced by the injection of antitoxin or a mixture of toxin and antitoxin, as in diphtheria or tetanus. That induced by the injection of vaccine, as in the protection against typhoid fever, dysentery, cholera, and plague by means of dead cultures of the specific organisms of these diseases. It has been demonstrated over and over again in epidemics of diphtheria that the injection of small doses of antitoxin into children exposed to infection serves to break up the epidemic. The latter form of artificially acquired immunity is, however, of short duration, lasting only from one to two months. The immunity acquired through injection of a mixture of toxin and antitoxin or through the injection of a vaccine is termed "active" immunity, while that conferred by means of antitoxin is "passive" immunity, because the body takes no part in its development. The immunity developed as the result of the employment of vaccines is active in character, though it probably does not last as long as does the immunity acquired through recovery from an attack of the disease.

With equal propriety we may speak of susceptibility as being either natural or acquired. Susceptibility may be said to have been acquired when disease is contracted because of the lowered tone of the body through the influence of the many factors which tend to destroy natural immunity. This is especially the case in children when an attack of some acute infectious disease follows before convalescence from some other disease has been completed.

A number of theories have been proposed to explain the phenomena of acquired immunity, but some of the earlier ones have been found to be erroneous and are no longer tenable. A few of the more important of these may be briefly stated before taking up those which are held at the present day. The first is the "exhaustion" theory proposed by Pasteur in 1880, which assumed that through the growth of the bacteria in the body they de-

stroyed some substance essential to their life and so made subsequent growth of the same species of bacteria impossible in such an individual, the complete destruction of this substance in the body conferring complete immunity. Another theory, known as the "retention" theory, proposed by Chauveau about the same time, which assumed that some product of the vital activity of the bacteria was retained in the system which was prejudicial to the subsequent development of the same species. Both of these theories have now been discarded as affording no satisfactory explanation of acquired immunity. Besides these, another theory has been proposed which, while presenting considerable evidence in explanation of the phenomenon, was not generally accepted because it failed to meet all the conditions. This is the "phagocytosis" theory, propounded by Metchnikoff in 1884. He demonstrated that certain cells of the body—the connective-tissue cells and the leukocytes—have the power of absorbing living bacteria from the fluids and tissues of the body. This fact can be very readily demonstrated experimentally by inoculating certain bacteria into animals. The presence in the blood of enormous numbers of leukocytes at certain stages of many bacterial diseases is likewise a strong indication that they have important functions to perform in these diseases. According to this theory, the extent of the affinity of the leukocytes for the bacteria is directly dependent upon the degree of immunity. After taking up the bacteria the leukocytes are carried in the blood-current to the large glandular organs, the liver and spleen, where they are probably destroyed along with their contained bacteria, or, in the case of wounds, they are cast off as pus with the other débris resulting from the disease-process.

The studies of Sir A. E. Wright and his associates have strengthened the "phagocytosis" theory of Metchnikoff, and it is now evident that the phagocytic powers of the leukocytes are due to the presence of certain antibodies in the blood—the opsonins—which first act upon the bacteria and prepare these for ingestion by the leukocytes.

In some of the bacterial diseases this type of immunity is of primary importance and constitutes the more important factor in the restoration of health. In other diseases phagocytosis plays a secondary *rôle* to other agents in the destruction of the invading micro-organisms. Such facts as the foregoing have demonstrated that acquired immunity in the different diseases is not due to the same factors, but is specific in each disease.

Another theory proposed to explain immunity is known as the "humoral" theory, and has been advanced by Buchner. It is well known that the serum of normal individuals has the power, to a considerable extent, of destroying bacteria, and on this fact Buchner based his theory that the pathogenic bacteria are destroyed within the body by the bactericidal action of the blood-plasma, and not by the leukocytes. Many of the normal fluids of the body also possess this bactericidal action to a certain extent. Buchner has applied the term alexins to the bactericidal proteid substances of the blood. Detailed studies upon the bactericidal influences of blood-serum have demonstrated that this effect is due to the presence of two substances, as will be seen in the elucidation of Ehrlich's theory of immunity.

In 1895 Pfeiffer published some experiments upon the effects of the peritoneal fluid of an animal immune against cholera upon the cholera organisms. He demonstrated that if an animal was rendered immune to cholera and then received an injection of cholera organisms into its peritoneal cavity, the injected organisms underwent rapid deterioration and were completely destroyed in a short time. These experiments demonstrated that immunity against the bacteria themselves was due not to protective substances normally present in the body, but to something which had developed during the course of immunization.

The demonstration by Bordet, in 1896, that one species of animal could be immunized against the blood of another species, and when so immunized the blood-serum of the immune animal was capable of dissolving the red

blood-corpuscles of the species with whose blood it had been immunized, opened up a new field of research which has afforded most valuable information upon the subject of immunity in general.

Ehrlich's Hypothesis.—In the light of our later knowledge upon the subject Ehrlich, in 1898, formulated his hypothesis of the mechanism of immunity which is receiving very general acceptance by scientists to-day. His theory of the mechanism of immunity is based upon Weigert's teaching of the process of tissue repair. It is a matter of universal observation that nature is prodigal in her attempts to repair an injury. This is shown in the healing process in an ordinary wound. A much larger amount of material is thrown out to bridge the chasm than is really utilized in the formation of new tissue. The presence of an excessive amount of new material is shown by the fact that the part is raised above the level of the surrounding sound tissue, and this excess is removed gradually as the newly formed tissue becomes stronger and stronger, until, finally, the wound is marked by a line of white scar tissue, the excess gradually passing into the blood current.

Ehrlich believed that the mechanism of immunity was explainable on a similar basis. It had become evident from the experiments of Wassermann with the tetanus bacillus that its toxin had an especial affinity for the cells of the central nervous system. Experiments with other bacteria pointed to the fact that the toxins of different species of bacteria had an especial affinity for the cells of different organs of the body. When the amount of poison entering the body is insufficient to destroy the cells which have an especial affinity for it, these cells may be injured only to such an extent as to permit subsequent repair. In order to comprehend Ehrlich's hypothesis, it is necessary to conceive the cells of the body as having a complex structure which may be stated diagrammatically as consisting of a central mass or nucleus from which radiate a number of "side chains," or lateral bonds, each of which serves to bind the cell to other sub-

stances. In the case of the cells of the central nervous system one of these lateral bonds has an especial affinity for tetanus toxin and suffers destruction. The cell now finds itself in unstable equilibrium, and at once proceeds to repair the damage wrought. As in the case of tissue repair, the new material produced to repair the breach is far in excess of the required amount. The excess finds its way into the blood-current. This material now circulating in the blood-current has the same affinity for tetanus toxin as when united with the central mass of a cell as its lateral bond, and can, therefore, combine with tetanus toxin floating in the blood-current, thus preserving other cells from injury. The union formed between the lateral bond of the cell, which is really the antitoxin, and the tetanus toxin results in the formation of a compound which is physiologically inert. According to Ehrlich's idea, therefore, the antitoxin is simply the excess of lateral bonds floating in the blood-current. This substance can neutralize the effect of the tetanus toxin in a test-tube just as readily as it does within the body.

This hypothesis of the mechanism of immunity has been very materially strengthened by the extension of Bordet's experiments upon the immunization of animals with alien bloods which Ehrlich made in collaboration with Morgenroth. From the results of these studies he has broadened his theory of immunity so that it serves to explain certain facts which were previously not fully comprehensible. Ehrlich recognizes three types of immunity which differ in their mechanism according to the nature of the substance employed in the immunization. Any protein substance which exerts an injurious effect upon the body-cells finds in these cells side chains with which it can unite. These side chains are called "receptors," and different kinds of receptors unite with different forms of foreign substances.

1. In the immunity conferred by toxins, when antitoxins are formed, Ehrlich conceives the receptors to be of the simplest nature, and he calls these uniceptors, or receptors of the first order. These receptors possess

simply one bond of attachment to which the toxin unites. These bonds of attachment he calls "haptophores," because they may be compared with prehensile arms. Similarly the toxin molecule also possesses a haptophore group through which it becomes attached to body cells and exerts its destructive action. When toxin and antitoxin are mixed *in vitro* in equal proportions, they unite with each other by means of their combining arms, and, in consequence, the toxin is neutralized.

2. In the immunization of animals with such substances as milk there is formed in the blood of the immune animal a substance which exerts a coagulating action when mixed with milk of the same species with which the immunization was brought about. This coagulation is produced by receptors circulating in the blood of the immune animal. These receptors differ somewhat from those of the first order in that they possess, in addition to the haptophore group, a zymophore group (so called from its enzyme-like capabilities) which brings about the coagulation. This constitutes the second order of receptors.

Receptors of a similar character are formed in the immunization of animals with serous fluids of other species. When the blood-serum of such an immune animal is mixed in a test-tube with the serum of the species of animal furnishing the blood for the immunization, a precipitate is formed. This test has now become of valuable service in medicolegal work in the detection of human blood. Old dried clots of blood can be taken up in physiologic salt solution and mixed with the serum of an animal immunized with human blood. If the blood-clot was of human origin, a precipitate will be formed. This is now the most delicate test that can be applied for the detection of human blood. Animals immunized with albuminous human urine give similar reactions to those immunized with whole blood or with blood-serum of human origin.

3. Ehrlich's studies of the mechanism of the immunity conferred by an alien blood revealed the fact that if the blood-serum of an animal immunized against an alien

blood was heated to 56° C. for half an hour, it lost its hemolytic power, but that this serum could again be rendered active by the addition of a drop of normal blood-serum. This fact demonstrated that the hemolytic power of the immune serum was dependent upon two substances: the one present in normal blood and destroyed by a low degree of heat, and the other present only in the serum of the immune animal and more resistant to heat. The first substance he named the "complement," because of its complementary action to the second substance, which he called the "immune body." He believes the complement to be of the nature of an enzyme, and, therefore, the substance through which the immune body really brings about the solution of the corpuscles. In his later communications Ehrlich calls the immune body the amboceptor. This name is indicative of the two combining arms or haptophores possessed by the immune body, the one serving to unite it with the complement, which he calls the complementophilic haptophore, and the other, the cytophilic haptophore, serving to unite it with the blood-corpuscle, bacterium, epithelial cell, etc., against which the animal has been immunized.

In the immunization of animals with bacteria, blood-corpuscles, epithelial cells, etc., there is formed a receptor having two haptophores—amboceptor or immune body. These are receptors of the third order. This amboceptor is specific for the particular cells employed in the immunization. If the animal has been immunized with the red blood-corpuscles of another species, the amboceptor has the property of uniting with the erythrocytes of that species of animal by one of its haptophores, while with the other haptophore it unites with the complement of the blood-serum and brings about solution of the corpuscles—hemolysis. The same effect is produced when the serum of an animal immunized with typhoid organisms is mixed with such organisms in a test-tube. The amboceptor unites with the bacilli with one of its haptophores, while with the other it unites with the complement existing in the blood-serum and brings about

the destruction of the organism—bacteriolysis. Immune serums which have been produced through the immunization of an animal with erythrocytes are known as hemolytic serums, while those produced through the immunization of an animal with certain species of bacteria are known as bacteriolytic or bacterial sera. A bacteriolytic serum produced by the immunization of an animal with Bacterium typhosum may be called a typhoid-immune serum, while a serum produced by the immunization of an animal with Bacterium dysenteriæ may be called a dysentery-immune serum, each serum being specific for the organism with which the animal has been immunized.

The hemolytic and bacteriolytic sera contain, in addition to the specific amboceptor, another receptor which is regarded as being of the second order, since it exerts an agglutinating effect upon the cells with which the animal has been immunized. This receptor is instrumental in bringing about the agglutination of the cells used in the immunization, and hence is called "agglutinin." The Gruber-Widal reaction, which is now so commonly employed in the diagnosis of certain diseases, rests upon the activity of this substance. When an immune serum containing agglutinin is mixed with the bacteria employed in the immunization, it brings about the clumping of the organisms which constitutes the Gruber-Widal test.

The complement or enzyme-like element of the blood-serum, which destroys the bacteria when brought in contact with them through the intermediation of the amboceptor, is a normal constituent of the blood. Ehrlich and his followers have demonstrated conclusively that there is a multiplicity of complements in normal blood.[1] According to Ehrlich's conception of the mechanism of immunity, the haptophores of the amboceptor and complement must fit each other like lock and key, so that unless both are of like configuration, they cannot unite. Fortunately, the human complements conform to those

[1] Ehrlich and Sachs, *Berlin. klin. Wochenschr.*, 1902.

of the domestic animals to a marked degree, so that animals of this character may be employed for the purpose of preparing immune serum.

The Antitoxic Sera.—It must be borne in mind that each of the different antitoxins known is specific for only one kind of poison, and this must be quite evident if Ehrlich's theory as to the mode of formation of antitoxins holds true. We know that in chemistry we have only one particular compound formed when we mix silver and hydrochloric acid together, and for the same reason each particular toxin or poison can lead to the formation of only one kind of antitoxin, and this antitoxin can probably neutralize only that particular kind of poison.

The antitoxin which is best known to-day and which is most successfully employed as a therapeutic agent is that of diphtheria. Diphtheria is a distinctly toxic disease; the symptoms and lesions, except those at the seat of infection, are almost entirely due to the action of the toxin circulating in the blood. The fever, debility, and the paralysis occurring during convalescence are probably entirely due to the action of the toxin. The bacilli are found in the membranous exudation forming upon the fauces, and occasionally in the later stages of the disease they are found in the lungs and the heart's blood.

Tetanus is also a purely toxic disease. The tetanus bacillus appears to be localized at the point of inoculation where it produces its toxin. The toxin is taken up by the peripheral nerves, and through these reaches the central nervous system, for which it has an especial affinity. It is possible to produce an efficient antitoxin against tetanus, but, on account of the affinity of the toxin for the cells of the central nervous system, the antitoxin has proved of less signal benefit in the treatment of the disease than is the case in diphtheria. By the time tetanic symptoms manifest themselves in tetanus such large numbers of the cells of the central nervous system have been injured by the toxin that the antitoxin frequently fails to preserve life. The subdural adminis-

tration of the antitoxin appears to give the most favorable results because it brings the antitoxin into closer proximity to the injured nerve-cells.

Probably the most signal benefit of the tetanus antitoxin has been as a prophylactic when administered early before the manifestation of tetanic symptoms in suspected cases of tetanus. There is at present no very positive method of determining the probability of infection by the tetanus bacillus, and hence the use of the tetanus antitoxin as a prophylactic is largely, if not entirely, empirical, but it should be used in all injuries where infection with tetanus spores is likely to occur. Since the prophylactic use of tetanus antitoxin has become general the incidence of tetanus infection has been greatly reduced, particularly in wounds following Fourth of July celebrations and in war wounds.

The Bacteriolytic Sera.—Antibodies are found in greater or lesser amounts in the blood of individuals suffering from the different bacterial diseases, and scientists have for a number of years been engaged in the study of the problems connected with the commercial production of immune sera.

In several bacterial diseases, as in typhoid fever, cholera, and to a large degree in dysentery, the immunity is of a bacteriolytic character, in that the blood-serum of convalescents contains much greater amounts of the specific amboceptors than are found in the blood of normal individuals.

Typhoid Immune Serum.—Among the earlier experimenters who studied the production of a typhoid immune serum are Lewin[1] and Jez,[2] and their results appeared to be quite promising. Beumer and Pfeiffer[3] were able to show that their serum had not only immunizing powers, but also curative powers.

Among the attempts to perfect an immune serum for typhoid fever the work of Chantemesse[4] is of interest.

[1] *Deutsche medicinische Wochenschrift*, January 19, 1899.
[2] *Wiener medicinische Wochenschrift*, February 18, 1899.
[3] *Zeitschrift für klinische Medicin*, Bd. xxviii.
[4] *L'Hygiene Gen. et Appliquee*, October, 1907.

His recent report on the subject is most encouraging, covering as it does the work of six years. He reports that in the 1000 patients subjected to this method of treatment during the past six years the mortality was 4.3 per cent., while the mortality in 5621 patients treated at the other hospitals of Paris during this period was 17 per cent. So far no antityphoid serum has been produced that has proved of definite value in the treatment of the disease.

Dysentery Immune Serum.—For some years an antidysentery serum has been on the market, but it has not given general satisfaction. The serum is principally bactericidal in its action. Recently it has been determined that the Shiga bacillus produces a soluble toxin of high potency, hence it may be possible that an antidysentery serum combining both bactericidal and antitoxic properties will prove more satisfactory.

The Opsonic Sera.—The immunity against the pyogenic bacteria, against pneumococcus, against plague bacillus, and against tuberculosis is not bacteriolytic to any degree, but is almost entirely opsonic in character. The opsonins prepare these bacteria for destruction by the body-cells, principally by the polymorphonuclear leukocytes.

Antistreptococcus Serum.—An antistreptococcus serum prepared by immunizing horses with streptococci from different sources, combining a number of strains of the organism, will yield a serum that is polyvalent in its action. If a serum of high potency is employed and given early in the infection in sufficient doses the results should be quite satisfactory. If there is time to determine the type of streptococcus that is causing the infection, whether it is *Streptococcus hemolyticus* or *Streptococcus viridans*, then a polyvalent type serum is likely to prove even more satisfactory.

The Antituberculosis Serum of Marmorek.—Wohlberg[1] ted 16 cases of tuberculosis with Marmorek's serum,

[1] *Berliner klinische Wochenschrift*, November 18, 1907, p. 1486.

and reaches the conclusion that the serum is of great value in the treatment of scrofulosis. In fully developed cases of tuberculosis the serum did not seem to be of definite service.

An antitubercle serum is also prepared by Parke, Davis & Co., Detroit. This is prepared by treating horses for several months with the toxic products of the tubercle germs.

Antimeningococcus Serum.—Flexner in America and Jochmann in Germany have prepared an antiserum for the treatment of cerebrospinal meningitis.

The antimeningococcus serum should be a highly potent, polyvalent serum. It should be administered intraspinally as early as possible. It should also be administered intravenously, because the infection is very commonly a systemic one as well as meningeal, especially in cases where a purpuric eruption has developed.

Prevention of Infection by Inducing Active Immunity.—An enormous amount of work has been performed to discover methods of preventing the action of pathogenic bacteria by means of their metabolic products.

The use of the metabolic products of the tubercle bacillus, the tuberculin of Koch, in the treatment of tuberculosis was not attended by the favorable results at first expected. This agent is, however, of great value as a diagnostic agent for the discovery of the presence of the disease in the early stages in man and animals. In this manner it becomes a most important preventive agent by the early discovery of the disease in cattle, thus limiting the danger of the dissemination of the disease through infected meat, milk, and milk products.

The increase of the relative immunity of individuals to diphtheria infection by the injection of a mixture of diphtheria toxin and antitoxin has recently come into general use in New York City as well as elsewhere. This mixture is employed in producing an active immunity of a higher grade than that obtained with antitoxin alone.

The valuable results obtained in the prophylactic treatment of cattle with anthrax vaccine—an attenuated culture of the anthrax bacillus; the important work of Pearson and Gilliland in the vaccination of cattle against tuberculosis; the prophylactic treatment of cattle with blackleg virus—a highly attenuated culture of the blackleg bacillus; the great value of active immunization of human beings against cholera, typhoid fever, and dysentery by injections of dead organisms; and the value of the prophylactic measures against small-pox and diphtheria as practised in the human family, lead us to hope that other prophylactic agents may be discovered to combat the development of infectious diseases.

Active immunity against typhoid, cholera, and plague is now obtained by the injection of the corresponding bacteria, killed by heating to 60° C. for one-half hour. These dead bacteria are injected in definite doses at stated intervals. Somewhat less satisfactory results have been obtained in inducing active immunity against pneumonia, meningitis, and influenza.

The Haffkine Method of Protection.—The first attempts at active immunization were made by Haffkine. He employed a living vaccine to bring about immunity to cholera. This vaccine consisted of strains of the cholera organism that had lost their virulence. Later Haffkine employed heated broth cultures of the plague organism to induce active immunity to plague.

Wright, of England, was the first to attempt immunization against typhoid fever with dead bacteria. He employed broth cultures that had been heated to 60° C. for one-half hour. The use of suspensions of typhoid bacilli in salt solution, as instituted on a large scale by Russell in the United States Army, has brought this type of vaccine into great prominence. More recently the suspension of the bacteria in oil, the so-called lipovaccines, has made it possible to inject larger doses without producing marked local or constitutional reactions.

With the view of overcoming the disadvantages of the

injections of the dead bacteria Besredka[1] injected a culture of an organism which had been treated with the specific amboceptors for that organism. It will be recalled that amboceptors are the intermediary bodies that bind the complement to the bacilli. The amboceptors resist heat, low degrees of which (56° C.) remove complement. For example, a culture of the typhoid bacillus was suspended in salt solution and enough heated antityphoid serum added to cause complete agglutination. The mixture was allowed to stand for six hours, during which time the bacteriolytic amboceptors, as well as the agglutinating bodies, are fixed to the bacteria. The bacteria were then washed free of serum by repeated centrifugating in salt solution. The sediment, consisting of typhoid bacilli plus the immune bodies, was then injected into animals. It was found that immediate immunity was conferred, which endured for at least five or six months. No general or local symptoms followed the injection; and this was true of an injection Besredka made himself. Vaccines of the type proposed by Besredka are now called "sensitized" vaccines or serobacterins, to distinguish them from those not treated with the specific immune substances.

Protective Immunization Against Plague.—W. Kolle and Richard P. Strong[2] experimented with a lowly virulent plague culture which had been cultivated four months at 41° to 43° C., so that it had become attenuated to such a degree that guinea-pigs and rats, which are very susceptible to plague, could withstand a millionfold the quantity of culture. It was shown by inoculations of forty-two human beings that this vaccine is without detrimental effect other than a slight fever and a slight local reaction, both of which disappeared within three days in 29 of these individuals. The blood was examined as to its agglutinating power as well as for its protective power when administered to animals, and was found to agglutinate

[1] Besredka, *Ann. de l'Inst. Past.*, 1902, vol. xvi, p. 918.

[2] *Deutsche med. Wochenschrift*, 1906, p. 413.

fresh plague cultures as well as to protect animals against inoculations of plague cultures.

It has been found, however, that living attenuated plague bacilli are unsafe, since they may revert to their former virulent state. For this reason heated plague bacilli or sensitized heated plague bacilli are now employed to induce active immunity.

Prophylactic Immunization Against Cholera.—Leon Karwacki[1] inoculated himself and ten other persons with cholera vaccine. At the first inoculation he employed one cubic centimeter, and at the second inoculation, made five days later, he employed two cubic centimeters, injected under the skin of the arm. The effects of the inoculations were reddening and swelling at the point of inoculation, and in some of the individuals swelling of the axillary lymphatics, a slight rise in temperature, never reaching 38° C., a slight general indisposition, and headache. After the second inoculation the reddening of the skin at the point of inoculation was the only effect noticed. Blood was drawn from these eleven persons before inoculation, five days after the first inoculation, and ten days after the second inoculation, and tested in regard to its bacteriolytic power. While the blood before the inoculation in its undiluted state in about half the tests gave a satisfactory Pfeiffer reaction, after the first inoculation the tests showed an average of fifty bacteriolytic units, and after the second inoculation it rose to 5000 to 10,000 units. In three convalescents from cholera the bacteriolytic power of one was of 1000 units and of the other two, 5000 units. The same increase in the agglutinating power was noted in the blood as the result of the inoculations. After the second inoculation the antibody formation reached about the height of that found in individuals who had recovered from cholera.

Immunization against cholera is carried out by the injection, at intervals of a week, of increasing doses of dead cholera organisms. Usually three such injections are given and the measurement of the degree of immunity

[1] *Zeitschr. f. Hyg.*, Bd. liv, p. 39.

induced, as by the agglutination or by the bactericidal test, shows that relatively high degrees of immunity are induced.

Protective Immunization Against Typhoid Fever.—No hygienic measure discovered in modern times compares in value with the beneficial effects which result from the prophylactic inoculation against typhoid fever. During the Spanish-American War, out of a total strength of 107,973 men, there were 20,738 cases of typhoid fever and 1580 deaths, representing 86.24 per cent. of the entire mortality of the war.[1]

Since vaccination against typhoid and paratyphoid fever has been made compulsory in 1911 in the United States Army and 1912 in the United States Navy, these diseases are no longer the cause for concern that they were formerly. Although the military forces were exposed to typhoid and paratyphoid infection both in camps and in the field, there were comparatively few cases during the World War. Some of the infections that did occur were traceable to the fact that immunization had not yet been completed, to oversight in properly completing the immunization, or possibly to defective vaccine. It may also be that the immunity developed after immunization is insufficient to the massive doses of the infecting bacilli that were swallowed by the individual.

At first three series of three injections, consisting of the typhoid bacillus, the paratyphoid *a*, and the paratyphoid *b* bacillus were given. Later on the three organisms were combined, suspended in salt solution, and three doses of this "triple" vaccine were given. Still later in the war the entire amount of organisms was incorporated in oil and injected at one dose. This is the so-called "lipovaccine."

During the year 1918 83 cases of typhoid and para-

[1] Russell, House of Representatives, Sixty-first Congress, Third Session, Document No. 1445, Washington, 1911.

typhoid fever occurred in the U. S. Navy, resulting in 9 deaths. The admission rate was 0.16 per 1000, the death-rate 1.78 per 100,000, and the case fatality rate 10.84 per 1000. The incidence of typhoid and paratyphoid fever in the U. S. Army was about the same as in the Navy.

Active Immunization Against Diphtheria.—In institutions where a number of childern are associated those that are susceptible to diphtheria infection may be detected by the Schick reaction, that is, by the intradermic administration of $\frac{1}{50}$ M. L. D. of diphtheria toxin. Those that give a positive reaction should be immunized by the administration of a mixture of diphtheria toxin and antitoxin. In this way an active immunity is induced.

Protective Immunization Against Whooping-cough.—Protective immunization against whooping-cough has been tried quite extensively in New York City, using killed cultures of Bacillus pertussis. Dr. Shaw, Director of Division of Child Hygiene, New York State Department of Health ("Health News," March, 1917), says: "The value of the vaccines as a prophylactic measure is undeniable, and they should be administered to every child exposed to whooping-cough." Although not every child that is immunized is protected against the disease, yet the proportion that develop the disease is quite low, only 4 per cent. of those treated with vaccines prepared by the New York City Health Laboratories developed the disease. Because of the unsatisfactory results of the treatment of the disease the relatively high mortality and the predisposition of an attack of whooping-cough to other diseases are important reasons for recommending the vaccines.

Protective Vaccination of Cattle Against Tuberculosis.—F. Hutyra[1] tested von Behring's method of vaccinating cattle, and the results obtained led to a quite optimistic expression of belief in the permanent value of this method, but later experiments have caused him to speak of the

[1] *Zeitschr. f. Tuberkulose*, 1917, pp. 97–122.

method with greater reserve. It appears that the resistance conferred by von Behring's method against subsequent intravenous injection with tubercle bacilli declines quite rapidly and disappears entirely toward the end of the first year. The resistance of inoculated cattle toward natural infection from other tuberculous cattle is never striking and disappears after a few months.

In further experiments to test von Behring's method two intravenous vaccinations were given in the place of one, as previously recommended. It was found that the resisting power of cattle thus treated was at first very pronounced or almost absolute, but that it was not of long duration, disappearing entirely within eighteen months. Hutyra concludes from his experiments that at present the only method for controlling tuberculosis which has stood practical test is that of Bang.

Value of Vaccination as a Protective against Small-pox.—Vaccination is the only preventive against small-pox. This has been demonstrated by the experience in countries where compulsory vaccination is in force, as well as in the experience of employees of small-pox hospitals. A single vaccination in infancy is usually not sufficient to protect against small-pox during life. Revaccination should be required at stated intervals, every five or seven years, where no small-pox exists. Whenever there is an outbreak in the community, all persons should be vaccinated at once and the revaccination continued as long as there is any reaction to the vaccine. Repeated vaccination until there is no longer any reaction is believed to be absolutely protective against small-pox. This is the only protection employed for physicians, nurses, and undertakers who come in daily contact with small-pox patients. It has been found that this form of protection is even more effective than a previous attack of small-pox, especially if some years have elapsed since the attack.

The extremely low death-rate from small-pox in Germany indicates the importance of re-vaccinations at stated intervals. It is also evident from observations in England

and America that both the incidence and the mortality of the disease are directly proportional to the protection afforded by vaccination as indicated by the number and distinctness of the vaccination marks.

Dr. William M. Welch, of the Municipal Hospital for Contagious and Infectious Diseases, Philadelphia,[1] states that "in every epidemic of small-pox that has occurred in Philadelphia within the past thirty years, instances have been observed of whole families having removed to the hospital because of an outbreak of the disease (small-pox) in these families. In such instances the unvaccinated children have suffered and often perished, while those who were vaccinated remained perfectly exempt, although living, eating, and sleeping in the infected atmosphere for several weeks. But I have yet to see a single unvaccinated child escape the disease under similar conditions of exposure. Furthermore, I have more than once seen a vaccinated infant take its daily supply of nourishment from the breast of its mother who was suffering from varioloid, and the infant continue as free from small-pox as if the disease were a hundred miles away, and the food derived from the most wholesome source. This is evidence of the prophylactic power of vaccination that does not appear in mortality reports nor in statistical records.

"Not many weeks since a pregnant woman nearly at term was admitted with varioloid. In the course of the disease labor occurred, and a male child weighing 8½ pounds was born. About five hours after its birth the infant was vaccinated, two insertions being made. Again, two days subsequently, two more insertions were made. Four large vaccine vesicles developed, causing a very sore arm, but did not give rise to any considerable elevation of temperature nor to any apparent disturbance of the health of the infant. After remaining in the hospital thirty-two days and proving its newly acquired immunity to small-pox in a most indubitable manner, the infant was taken home by its mother,

[1] *American Medicine*, 1902, vol. iv.

who had made a good recovery without untoward symptoms."

Vaccine virus is prepared with all precautions against the dissemination of infection. The virus is obtained from healthy calves. The calves are first tested for tuberculosis, glanders, anthrax, and tetanus. If they are found free from infection, they are scrubbed with soap and water and transferred to special stables where they are kept under the most cleanly conditions. In order to inoculate them with the virus they are again washed and scrubbed. The hair on the anterior surface of the body is clipped, the skin shaved, and then scarified. The virus is rubbed into the scarified area. When the vesicles have developed the calf is killed and the entire area containing the vesicles is cureted and the pulp obtained is mixed with 50 per cent. glycerin in water and ground in a machine until the pulp is thoroughly emulsified. The glycerinated virus contains numerous bacteria, principally saprophytes, from the skin of the animal. The virus is now placed in cold storage and cultures are made from time to time to note the disappearance of the bacteria. When the cultures show that the reduction in bacteria has progressed to the desired point and that none of the bacteria still present are harmful to human beings, the virus is placed in capillary glass tubes and marketed. The glycerinated virus will not keep indefinitely, as the specific agent is also killed by the glycerin if kept too long. The virus should be kept in an ice-box, as it loses its effectiveness rather quickly if it is kept at room temperature.

Precautions in Vaccination.—More or less objection to vaccination is encountered in some communities. This objection may be divided into several different classes: (1) That of the anti-vaccinationists, which it is not necessary to consider here. (2) That of those who fear the transmission of some disease in the vaccine. This objection is groundless at the present day, since all the vaccine on the market is of bovine origin. It is

doubtful whether any cases of tetanus following vaccination have been certainly traced to the vaccine virus. (3) That of those who fear the development of very sore arms with danger of blood-poisoning. This danger is largely due to the ignorance and neglect of the vaccinated. In order to avoid unnecessary discomfort in this respect, the operation should be conducted under aseptic precautions and the vaccination wound properly protected. The arm should be first thoroughly washed with soap and water and the site of the operation then washed with alcohol. After the vaccination is made the site should be protected from rubbing by means of a piece of clean soft muslin pinned to the undershirt. This should be changed each day until the scab falls off. It is probable that this procedure is far preferable to the use of the different forms of shields which have been placed on the market in recent years. Great care must be exercised to prevent the rupture of the vesicle or the premature removal of the scab. Should either of these contingencies occur, the vaccination should be treated like any other open wound.

The vaccination operation consists in exposing the true skin by removing the cuticle by means of a blunt sterilized needle. No blood should be drawn in the operation. The exposed area should not exceed five millimeters in diameter (one-fourth of an inch).

Biologic Aids to Diagnosis.—The importance of the early diagnosis of transmissible diseases cannot be too strongly emphasized, and we must welcome, therefore, everything that will render an early diagnosis more certain. In addition to the direct bacteriological examinations, as applied to the diagnosis of diphtheria, tuberculosis, gonorrhea, cerebrospinal meningitis, and other diseases, we have for a number of years employed the agglutination reaction for the early diagnosis of typhoid fever, and the tuberculin test for the detection of tuberculosis. During recent years we have added several important additional aids to diagnosis and to our management of transmissible diseases.

Von Pirquet called attention, on May 8, 1907, to the fact that tuberculosis can be diagnosed in children by the introduction, into cutaneous scarifications, of 25 per cent. tuberculin, the reaction being the formation of a typical papule at the point of instillation in those that are tubercular, while no reaction is seen in non-tubercular persons. A week later Wolff-Eisner reported that a similar reaction could be obtained by the instillation of 10 per cent. tuberculin into the conjunctival sac. Calmette has since advised the use of a 1 per cent. tuberculin for the eye reaction.

Chantemesse[1] reports on an ophthalmo-diagnostic test in typhoid fever, which consists of the instillation, into the conjunctival sac, of ½ mg. of a dry powder obtained from typhoid bacilli, suspended in a drop of water, which calls forth a reaction in those suffering from typhoid fever, while it is without effect in healthy individuals. He found this ophthalmic reaction to antedate the agglutination reaction by several days. In 70 typhoid patients the reaction was positive in each instance, while it was negative in 50 non-typhoid individuals.

Deehan[1] has perfected an extract from the typhoid bacillus which, in his hands, served to diagnose typhoid fever when employed in cutaneous scarifications.

Martel[2] has demonstrated that the von Pirquet cutaneous reaction, as well as the ophthalmic reaction, can be successfully produced with mallein in individuals who suffer from glanders. In every individual suffering from glanders that was tested there was a definite reaction, while there was no effect in healthy individuals. Mallein was used in 1 : 10 to 1 : 4 dilution for the cutaneous test, and in 1 : 60 dilution for the ophthalmic test.

The Shick method of determining the degree of susceptibility to diphtheria infection by the intradermal injection of diphtheria toxin has been found very valuable.

[1] *Deutsche med. Wochenschrift*, 1907, p. 1572.
[2] *Univ. of Penna., Med. Mag.*, 1909.
[3] *Berliner klin. Wochenschrift*, Bd. xlv, p. 451.

Wassermann, Neisser, and Bruck[1] have proposed a serum diagnostic test for syphilis which is based upon the complement binding method of Bordet and Gengou. They found that the serum of monkeys that had been treated with syphilitic material after a time acquired the property of binding complement when brought in relation with extracts of syphilitic materials. If now there are added a heated hemolytic serum and blood-corpuscles, no hemolysis takes place, since the complement has been combined with an antibody in the syphilitic serum.

The Wassermann test for syphilis has become a routine laboratory procedure for the purpose of detecting the disease and also to determine the effect of specific treatment. A positive Wassermann reaction in a suspected case of syphilis is generally regarded as indicative of infection, while a negative test, though not always a certain indication of the absence of infection, is generally accepted as indicative of the absence of infection, unless there are other symptoms or conditions pointing to infection.

A test of a similar nature, the complement-fixation test, is of value in the diagnosis of other obscure infections besides syphilis. This test is used in the diagnosis of suspected infections by staphylococci, streptococci, pneumococci; in the detection of glanders, and for the diagnosis of tuberculosis. Cancer and other tumor formations can also be differentiated by the complement-fixation test.

Michaelis[2] has found that it is possible to diagnose the presence of syphilis by means of a precipitation reaction when syphilitic serum and syphilitic liver extract are mixed in certain definite proportions. The precipitation reaction is not produced with normal serum and syphilitic liver extract, nor with syphilitic serum and normal liver extract.

[1] *Deutsche med. Wochenschrift*, 1906, p. 745.

[2] *Berliner klin. Wochenschrift*, Bd. xlvi, p. 1477, November 18, 1907.

Another diagnostic test in syphilis is the luetin reaction. Cultures of Treponema pallidum are ground up into a thick paste until a homogeneous emulsion is obtained. The emulsion is heated in a water-bath at 60° C. and preserved with phenol or tricresol. In positive cases of syphilis a raised, reddish, indurated papule forms when the material is injected intradermally. The test is less trustworthy in chronic infection than the Wassermann test.

Personal Prophylaxis.—In treating cases of infectious diseases, it is inadvisable for the physician to wear specially constructed suits for his protection against infection. There are, however, a number of precautionary measures that should be taken. The physician may wear a linen duster or operating-coat over his clothing while in the sick-room, since this will not be so likely to alarm the patient, and will serve in a large measure to keep infective materials from his own clothing. This coat should be left in an ante-room or just outside the door of the sick-room, and should be disinfected after each visit in such diseases as small-pox and scarlet fever. He should time his visits so as to have a full stomach, and should spend as much time as possible in the open air subsequently. He should secure at least eight hours of sleep, so as to maintain his physical vigor. He should abstain from the use of alcoholic beverages. Personal cleanliness is of the greatest importance, and daily baths are to be recommended. Great care should be taken in keeping the hands and nails scrupulously clean, and it is advisable for the physician to wash his hands immediately after handling the patient. There is no doubt that many physicians have lost their lives in consequence of neglect of this point. This is especially true of typhoid fever, where the patient's body and clothing are soiled by fecal matter and urine. The same precautions apply with equal, or even greater, force to the nurse. Drugs have no influence whatever in warding off disease, though there is a widespread belief to the contrary among the laity.

The Etiologic Factor, Avenues of Entrance, Sources of Infection, Modes of Dissemination, and Chief Preventive Measures of the Principal Acute Infectious Diseases.

Disease.	Etiologic factor.	Avenues of entrance.	Sources of infection.	Modes of dissemination.	Preventive measures.
Pneumonia . .	Bacterium pneumoniæ	Respiratory	Direct and indirect contact	Sputum	Isolation and disinfection.
Diphtheria . .	Mycobacterium diphtheriæ	"	Direct and indirect contact	Saliva	Isolation, disinfection, and antitoxin.
Typhoid fever Paratyphoid fever . . .	Bacterium typhosum Bacterium paratyphosum	Alimentary "	Water and food and contact	Feces and urine Feces	Isolation, disinfection, boiling water, and food. Immunization.
Yellow fever. .	Leptospira icteroides	Local	Mosquito bites	Infected mosquitoes	Isolation, disinfection, and exclusion of mosquitoes.
Tuberculosis . .	Bacterium tuberculosis	"	Direct and indirect contact	Sputum and pus	Isolation and disinfection.
Erysipelas. . .	Streptococcus pyogenes	"	Direct and indirect contact	Secretions, epithelial cells	" " "
Cholera	Vibrio choleræ	Alimentary	Water and food	Feces	Isolation, disinfection, boiling water, and food. Immunization.
Cerebrospinal meningitis	M. intracellularis	Respiratory (?)	Direct and indirect contact	Excretions	Isolation and disinfection.
Influenza . . .	Bacterium influenzæ	Respiratory	Direct and indirect contact	Sputum	" " "
Tetanus. . . .	Clostridium tetani	Local	Infected dust	Pus	" " "
Plague	Bacterium pestis	"	Flea bites	Fleas	Isolation. Destruction of Rats. Immunization.
Gonorrhea. . .	Neisseria gonorrhœæ	"	Secretions	Pus	Isolation and disinfection.
Anthrax. . . .	Bacillus anthracis	"	Secretions and dust, fomites	"	" " "
Malignant edema	Clostridium œdemæ	"	Infected dust	Secretions	" " "
Relapsing fever	Spirochæta obermeieri	Bites of insects	Ticks, bedbugs, lice.	Insects	Destruction of ticks, bedbugs, and lice.

Leprosy. . . .	Bacterium lepræ	Local	Fomites and secretions	Secretions	Isolation and disinfection.
Syphilis. . . .	Treponema pallidum	"	Secretions from lesions	"	" " "
Glanders . . .	Bacterium mallei	"	Secretions	"	" " "
Actinomycosis .	Actinomyces bovis	"	"	"	" " "
Small-pox . . .	Unknown	Unknown	Fomites	Desquamations	Vaccination.
Measles. . . .	"	"	"	"	Isolation and disinfection.
Scarlet fever . .	"	"	"	"	" " "
Mumps	"	Respiratory	"	Saliva	" " "
Whooping-cough	Bacillus pertussis.	"	Contact	Sputum	" " "
Malaria	Plasmodium malariæ	Local	Mosquito-bites	Mosquitoes	Exclusion of mosquitoes and isolation of cases. Quinin.
Filaria	Filaria sanguinis hominis	"	"	"	Exclusion of mosquitoes and isolation of cases.
Carbuncle . . .	Staphylococcus pyogenes	"	Contact	Pus	Isolation and disinfection.
Trichinosis . .	Trichinella spiralis	Alimentary	Diseased meat	Feces	Destruction of diseased animals and meat.
Favus	Achorion Schönleinii	Local	Contact	Secretions	Isolation and disinfection.
Dysentery. . .	Bacterium dysenteriæ	Alimentary	Water and milk	Feces	Isolation, disinfection, boiling water and food.
Botulismus . .	Bacillus botulinus	"	Infected meat.		
Varicella . . .	Unknown	Unknown	Fomites	Desquamations	Isolation and disinfection.
Dengue. . . .	"	"	Mosquito bites	Mosquitoes	Exclusion of mosquitoes
Typhus fever. .	"	"	Lice	Lice	" " lice.
Rabies	"	Local	Bite of animal	Saliva	Cauterization of wound, killing of diseased animals, and muzzling of dogs.
Poliomyelitis .	"	Unknown	. . . .	. . . .	Isolation and disinfection.
Scabies	Sarcoptes scabiei	Local	Direct contact	Direct contact	Isolation and disinfection.
Enteritis . . .	Bacterium enteritidis	Alimentary	Infected water and milk	Feces	Boiling water and milk.

Physicians as Carriers of Infection.—Dr. A. G. Young, Secretary of the Maine State Board of Health, gives the following method practised by him in rural districts to prevent the carrying of infection.

When visiting cases of small-pox, diphtheria, or other infectious diseases, a good method of procedure is to leave overcoat, hat, undercoat, and usually collar and necktie outside of the house containing the patient. Call for an earthenware washbowl from the house and a quart of hot water—nothing else. From a small and tightly closing bag take out a bottle of bichlorid tablets, one or two of which are dropped into the washbowl to be dissolving while inside; then take out and slip on a pair of white duck trousers, then a barber's white coat with an extra button which buttons up closely around the neck. Rubber bands around the ends of the sleeves of the coat and a silk skull-cap complete the attire. After leaving the infected room soak the hands in the bichlorid solution, remove a towel from the grip, a two-ounce vial of formaldehyd solution, and two surgeon's hand-brushes. Then take off the white coat and trousers, roll them up carefully, and place them in the grip with the cap. Then wash the hands again in the disinfecting solution, and wash the wrists, head, face, and neck, wetting the hair thoroughly. Dipping the brushes in the bichlorid solution, scrub down the clothing, particularly the lower part of the trousers, and finally the boots. Then all the remaining things are placed in the grip, the towel on top. Upon this towel pour an ounce or more of formaldehyd solution, and close the grip immediately. The things are disinfected in five or six hours. The bag usually remains closed the following night, and the next morning is opened and the things are aired for further use.

The following scheme is one that is very easily applied and has been adopted by hundreds of physicians as at once practical and effective:

After contact with a contagious case, the clothing is removed and hung in a tight closet, a Schering lamp lighted and placed therein, and the closet-

door shut. If the closet is tight, the clothing hung loosely, and the door kept closed while the lamp is burning, five or six hours' contact will give efficient disinfection.

The sick room should be as devoid of furniture and carpets as is compatible with the comfort of the patient and the attendants. The furniture should be simple and easily cleaned. No sweeping should be permitted in the sick room. The room should be kept clean by wiping all horizontal surfaces with a cloth moistened with a disinfectant solution. When more thorough cleansing is required, soap and hot water should be used. Everything taken from the sick room should be disinfected either before removal or it should be removed in such a way as to prevent the dissemination of infectious materials, and disinfected after removal.

In the preceding table an attempt has been made to present in concise form the more important points with regard to the direction in which it is necessary to extend our energies in controlling the principal infectious diseases. Not all of the preventive measures employed in the different diseases are here given, but only those which are deemed to be the leading measures. The details with regard to the special modes of disinfection adapted to the more important of these diseases are given in the chapter on Disinfection.

Persistence of Pathogenic Bacteria in Dead Bodies.—The possible danger of the infection of the soil and water through pathogenic bacteria derived from dead bodies after burial has been frequently discussed.[1] Klein has made a practical investigation of the subject. He inoculated guinea-pigs intraperitoneally with different organisms, and after death they were wrapped in cotton, placed in small wooden or tin boxes, or without these, and buried in moist earth or sand. When exhumed, the abdominal cavity of the animals was opened and washed out with 1 or 2 cubic centimeters of sterile salt solution, and this fluid was used to make cultures. Bacillus pro-

[1] *Centralbl. f. Bacteriologie*, Bd. xxv, S. 727.

digiosus and Staphylococcus aureus were found alive after twenty-eight days, but had disappeared entirely in six to eight weeks. Cholera organisms were found alive after nineteen days, but had disappeared after twenty-eight days. Similar results were obtained with typhoid, diphtheria, and plague bacilli. Tubercle bacilli died during the first seven weeks. The studies of Gildersleeve[1] show that virulent bacteria, such as Bacillus tuberculosis and Staphylococcus pyogenes aureus, can be recovered from dead bodies in the dissecting-room. Bodies preserved in strong brine or kept in cold storage for as long as six months still contained the virulent bacteria.

These results indicate that there is danger of the contamination of the soil and water in the vicinity of cemeteries when the bodies of those dying from infectious diseases are not disposed of in a proper manner. The bodies should be wrapped in sheets moistened with 1 : 1000 bichlorid of mercury solution, or 5 per cent. carbolic acid solution; all the orifices should first be efficiently plugged. The bodies should be placed in hermetically sealed coffins, so that there is no possibility for the infectious material to escape. Cremation would be the quickest and safest method of disposal of the bodies of persons dying of infectious diseases, but this mode of disposal is objectionable to many persons.

Lobar Pneumonia.—This is an infectious disease transmitted from one individual to the other in which the organism is conveyed in the saliva, sputum, or the nasal discharges, either directly or indirectly. Many normal persons carry virulent pneumococci in their oral cavity, and are, therefore, potential carriers, if not actually so. In ordinary pursuits the dissemination of the infection is slight because of the high natural resistance of most persons. In military organizations or other localities where large numbers of persons are closely associated the danger of dissemination is much greater.

[1] *Univ. Penna. Med. Bull.*, November, 1901.

The greatest factors in the dissemination of the pneumococcus are overcrowding, deficient ventilation, especially of sleeping quarters, dampness of quarters, wearing of wet clothing, overwork, and promiscuous spitting.

The patient with pneumonia should be isolated in an appropriate ward. Strict care should be exercised in disinfecting all discharges of the respiratory tract, as these contain the pneumococcus in countless numbers. Cross-infection of patients in adjacent beds should be guarded against by the use of the cubicle system.

The patient's sputum should be typed as soon as possible, and if the infection is due to Type I pneumococcus he should receive the antipneumococcus serum in doses of 50 to 100 c.c. administered intravenously.

During the war a number of studies were carried out in the prophylactic vaccination against pneumonia. Cecil and Vaughan[1] made 13,460 vaccinations at Camp Wheeler, on about 80 per cent. of the entire camp personnel, using lipovaccine. The dosage was 1 c.c. containing approximately 10,000,000,000 each of pneumococcus Types I, II, and III. The troops were under observation for two to three months after vaccination. During this time there occurred 32 cases of pneumonia due to Types I, II, and III pneumococcus among the vaccinated four-fifths of the camp and 42 cases of pneumonia of these types among the unvaccinated one-fifth of the camp. However, 24 of the 32 cases of pneumonia in the vaccinated occurred within one week after vaccination, evidently during a time when incomplete immunity had developed from the inoculations.

Cecil and Austin[2] carried out 12,519 vaccinations against pneumococcus Types I, II, and III at Camp Upton. During ten weeks that elapsed following the vaccinations no cases of pneumonia occurred in the men who had received two or three doses of the vaccine. Among approximately 20,000 men in the camp that were

[1] *Jour. Exp. Med.*, xxix, 1919, 457.

[2] Ibid., xxviii, 1918, 19.

not vaccinated there were 26 cases of pneumonia during the same period.

Brown and Palfrey[1] report on the immunization of 2029 men in Camp Greene, using the U. S. Army lipovaccine. The total strength of the organization was 3664. Therefore 55.4 per cent. were vaccinated and 44.6 per cent. were not vaccinated. Up to the time of demobilization of the camp 13 of the vaccinated and 30 of the unvaccinated developed pneumonia. Although less than one-half of the command remained unvaccinated they developed nearly two and one-half times as many cases of pneumonia as the vaccinated.

Diphtheria.—The detection of a diphtheria patient among a group of individuals calls for prompt isolation of the patient and his treatment with diphtheria antitoxin. The antitoxin should be administered as early as possible, because the sooner this is done, the better the chances for recovery. For adults the following amounts of antitoxin should be given:

Mild cases, 3000 to 5000 units by subcutaneous or intramuscular injection.
Moderate cases, 5000 to 10,000 units by subcutaneous or intramuscular injection.
Severe cases, 10,000 to 20,000 units by intramuscular or intravenous injection.
Malignant cases, 20,000 to 40,000 units by intramuscular or intravenous injection.

All contacts with diphtheria patients should be segregated and cultures made of the nose and throat. At the same time a Schick test should be made. All those having positive throat cultures should be treated as actual diphtheria cases. Those with a positive Schick test should be actively immunized against diphtheria by receiving three injections of the toxin-antitoxin mixture.

The Schick test for susceptibility to diphtheria infection consists in the intradermic injection of $\frac{1}{50}$ of an M. L. D. of diphtheria toxin contained in 0.2 c.c. of sterile

[1] *N. Y. Med. Jour.*, Aug. 23 and 30, 1919.

salt solution. At the same time a control test is made with an equal quantity of heated toxin so as to differentiate between a positive reaction caused by the toxin and a pseudoreaction caused by the ingredients of the culture-medium in which the diphtheria organism had been cultivated. A dark red area, circumscribed in outline, and $\frac{1}{2}$ of 1 cm. in diameter, without any reaction in the control test, indicates a positive reaction. The reading is made after seventy-two hours. A negative reaction indicates that the person has at least $\frac{1}{30}$ unit of antitoxin in each cubic centimeter of his blood, and is protected against diphtheria infection.

Persons with a positive Schick reaction should be immunized by receiving three injections, at intervals of a week, of a mixture of diphtheria toxin and antitoxin. This mixture contains $\frac{8}{10}$ of an L_+ dose of toxin to 1 unit of antitoxin. A great deal of suffering from diphtheria infection could be avoided if all children two years of age and over were given the Schick test, and those showing a positive reaction were rendered actively immune by receiving the toxin-antitoxin injections.

Diphtheria patients and carriers of the bacillus should be held in isolation until at least three negative cultures of the nose and throat have been obtained.

Recently Havens[1] reported on agglutination tests with the serum of rabbits immunized to the diphtheria bacillus. He found that of 206 cultures studied 82 per cent. were agglutinated with the serum of a rabbit immunized with a typical diphtheria organism, while 18 per cent. of the cultures were not agglutinated. A rabbit immunized with one of the latter group of organisms furnished a serum that agglutinated all of the members of that group, but none of the larger group. Other immunity tests of the two groups showed that antitoxin prepared by immunizing animals with the toxin of the larger group had no effect on the infection by the smaller

[1] *Jour. Infect. Dis.*, xxvi, 1920, 388.

The Etiologic Factor, Avenues of Entrance, Sources of Infection, Modes of Dissemination, and Chief Preventive Measures of the Principal Acute Infectious Diseases.

Disease.	Etiologic factor.	Avenues of entrance.	Sources of infection.	Modes of dissemination.	Preventive measures.
Pneumonia . .	Bacterium pneumoniæ	Respiratory	Direct and indirect contact	Sputum	Isolation and disinfection.
Diphtheria . .	Mycobacterium diphtheriæ	"	Direct and indirect contact	Saliva	Isolation, disinfection, and antitoxin.
Typhoid fever Paratyphoid fever . . .	Bacterium typhosum Bacterium paratyphosum	Alimentary "	Water and food and contact	Feces and urine Feces	Isolation, disinfection, boiling water, and food. Immunization.
Yellow fever. .	Leptospira icteroides	Local	Mosquito bites	Infected mosquitoes	Isolation, disinfection, and exclusion of mosquitoes.
Tuberculosis . .	Bacterium tuberculosis	"	Direct and indirect contact	Sputum and pus	Isolation and disinfection.
Erysipelas. . .	Streptococcus pyogenes	"	Direct and indirect contact	Secretions, epithelial cells	" " "
Cholera	Vibrio choleræ	Alimentary	Water and food	Feces	Isolation, disinfection, boiling water, and food. Immunization.
Cerebrospinal meningitis	M. intracellularis	Respiratory (?)	Direct and indirect contact	Excretions	Isolation and disinfection.
Influenza . . .	Bacterium influenzæ	Respiratory	Direct and indirect contact	Sputum	" " "
Tetanus. . . .	Clostridium tetani	Local	Infected dust	Pus	" " "
Plague	Bacterium pestis	"	Flea bites	Fleas	Isolation. Destruction of Rats. Immunization.
Gonorrhea. . .	Neisseria gonorrhœæ	"	Secretions	Pus	Isolation and disinfection.
Anthrax. . . .	Bacillus anthracis	"	Secretions and dust, fomites	"	" " "
Malignant edema	Clostridium œdemæ	"	Infected dust	Secretions	" " "
Relapsing fever	Spirochæta obermeieri	Bites of insects	Ticks, bedbugs, lice.	Insects	Destruction of ticks, bedbugs, and lice.

Leprosy. . . .	Bacterium lepræ	Local	Fomites and secretions	Secretions	Isolation and disinfection.
Syphilis. . . .	Treponema pallidum	"	Secretions from lesions	"	" " "
Glanders . . .	Bacterium mallei	"	Secretions	"	" " "
Actinomycosis .	Actinomyces bovis	"	"	"	" " "
Small-pox . . .	Unknown	Unknown	Fomites	Desquamations	Vaccination.
Measles. . . .	"	"	"	"	Isolation and disinfection.
Scarlet fever . .	"	"	"	"	" " "
Mumps	"	Respiratory	"	Saliva	" " "
Whooping-cough	Bacillus pertussis.	"	Contact	Sputum	" " "
Malaria	Plasmodium malariæ	Local	Mosquito-bites	Mosquitoes	Exclusion of mosquitoes and isolation of cases. Quinin.
Filaria	Filaria sanguinis hominis	"	"	"	Exclusion of mosquitoes and isolation of cases.
Carbuncle . . .	Staphylococcus pyogenes	"	Contact	Pus	Isolation and disinfection.
Trichinosis . .	Trichinella spiralis	Alimentary	Diseased meat	Feces	Destruction of diseased animals and meat.
Favus	Achorion Schönleinii	Local	Contact	Secretions	Isolation and disinfection.
Dysentery. . .	Bacterium dysenteriæ	Alimentary	Water and milk	Feces	Isolation, disinfection, boiling water and food.
Botulismus . .	Bacillus botulinus	"	Infected meat.		
Varicella . . .	Unknown	Unknown	Fomites	Desquamations	Isolation and disinfection.
Dengue. . . .	"	"	Mosquito bites	Mosquitoes	Exclusion of mosquitoes
Typhus fever. .	"	"	Lice	Lice	" " lice.
Rabies	"	Local	Bite of animal	Saliva	Cauterization of wound, killing of diseased animals, and muzzling of dogs.
Poliomyelitis .	"	Unknown	. . . .	. . . .	Isolation and disinfection.
Scabies	Sarcoptes scabiei	Local	Direct contact	Direct contact	Isolation and disinfection.
Enteritis . . .	Bacterium enteritidis	Alimentary	Infected water and milk	Feces	Boiling water and milk.

the organism in the nasopharynx. Infection occurs through the upper respiratory tract by direct or indirect contact with patients or carriers. Catarrhal conditions of the upper respiratory tract predispose to the infection, as do also overcrowding, deficient ventilation of sleeping quarters, and promiscuous coughing and spitting.

The suspected meningitis patient is sent to the hospital as soon as possible. The diagnosis is confirmed by lumbar puncture and examination of the spinal fluid. Intraspinous and intravenous injections of polyvalent antimeningococcus serum are to be made at once, especially if the clinical symptoms are fairly clear, if the spinal fluid is turbid, and issues under increased pressure.

All contacts with a meningitis patient should be segregated and bacteriologic examination made of the nasopharynx. All carriers of the meningococcus should be isolated and treated with antiseptic throat sprays until the organisms have disappeared from the nasopharynx.

Gordon[1] and his associates demonstrated the existence of four distinct serologic types of the meningococcus. This finding is important in tracing the origin of infection. If carriers are found with a type of meningococcus similar to that found in a patient in the same group of individuals there is a possibility that the patient may have contracted the infection from the carrier. If, however, the carrier harbors a type of meningococcus different from that affecting the patient, then infection from the particular carrier is excluded.

The prophylactic use of polyvalent meningococcus vaccine has been tried, and there is a strong probability that this procedure is of value, at least for a short time, as definite antibody formation in the blood of immunized persons has been proved.

Cerebrospinal meningitis during the year 1917 was especially prevalent in Pennsylvania, Ohio, New York, Illinois, Minnesota, and Connecticut. This accounted

[1] *Med. Research Com., Special Report*, No. 3, London, 1917.

for, in part at least, the frequent occurrence of the disease in the military camps. The greatest number of cases occur during the months of March, April, and May. though the disease prevails throughout the year. In the military camps the disease appeared to have its highest incidence during the months of January and February.

Mumps.—The causative factor of mumps remains undetermined. Since it is primarily an infectious disease of the salivary glands, we may assume that the infectious agent gains entrance through the mouth by direct or indirect contact and finds its way to the parotid gland, the most frequent seat of the disease. Wollstein[1] found that the saliva contains a filterable virus. The virus gains access to the blood-stream during the course of the disease. The period of incubation ranges from eight to thirty days, the average period being about eighteen days. The disease is infectious from the time of the prodromal symptoms, and remains infectious for a period of about ten days after the subsidence of the acute symptoms.

Influenza.—Though a great deal of uncertainty arose during 1918 as to the exact causative agent in influenza, there is evidence that the studies of the Pfeiffer bacillus during the past year support the earlier assumption that this organism is the primary cause of the disease. The great fatality of the disease during the latter part of 1918 is generally conceded to have been traceable to the mixed infections due to pneumococcus and streptococcus. By far the greater number of deaths resulted from pneumonia, generally of a "patchy" nature, and the lungs at autopsy contained pneumococci and streptococci besides the influenza bacillus.

Prophylactic measures against influenza have not been very successful, as a rule, because it has been impossible to guard against all the ways in which the infection is disseminated. The disease traveled from one

[1] *Jour. Exp. Med.*, 1916, xxvii, 353.

place to another as fast as human beings that carried the infecting organism were conveyed by train or boat. That it is possible to protect against the infection by quarantine is shown by the successful exclusion of the disease from the Commonwealth of Australia during the months of October, November, and December, 1918, when the disease prevailed in every other country. The exclusion from Australia was accomplished by strict maratime quarantine.

The disease is most commonly conveyed by "hand-to-mouth" infection. It may be disseminated on eating utensils where these are not disinfected with boiling water. It may be disseminated by indirect contact through objects that have been infected by those having the disease, especially by mild cases, as through the agency of money, pencils, cigarettes, and toilet articles.

Disinfection of all discharges of the respiratory tract of patients is essential. Particular attention must be given to the milder cases so as to bring them under proper supervision. Attendants should wear masks so as to protect themselves, and must disinfect their hands frequently.

Howard and Love[1] give the incidence of influenza in the U. S. Army according to nativity, admission rates for influenza and pneumonia among enlisted men, white and colored, in the United States and Europe during 1918. They give the following summary of their studies:

1. Influenza prevailed much more extensively in the Army in 1917 and during the early months of 1918 than has been commonly recognized. There were 40,512 cases of this disease reported in the Army for the year 1917.

2. Unrecognized influenza was probably the primary and underlying cause of the atypical and fatal pneumonic infections occurring in the army camps during 1917 and the early part of 1918, in addition to the cases known to have been associated with measles.

[1] *Military Surgeon*, xlvi, 1920, 522.

3. Influenza in 1917 and the early months of 1918 was relatively mild in type as compared with the virulent type of the disease which appeared in the army camps in September, 1918.

4. The extension of the virulent influenza from Camp Devens to other camps south and west in September, 1918, can be traced in many instances directly to the intercharge of military personnel from infected camps. The contagion was transferred by persons either themselves infected or who were carriers of the disease, and the extension definitely followed ordinary lines of travel.

5. The height of the September outbreak of the disease in the United States extended over a period of about nine weeks (September 13 to November 15, 1918). During this period over 20,000 deaths occurred among troops in the United States alone in excess of the number that would have occurred if the disease death-rate for the corresponding period of the preceding year had prevailed.

6. The height of the epidemic in France extended over the same period of time as in the United States.

7. Influenza and pneumonia were less prevalent and less fatal among the troops in France than in the United States.

8. The "cantonment" group of stations gave much higher death-rates from influenza and its complications than other groups. (Tent camps or permanent posts.)

9. For the entire Army (approximately 3,500,000 men) there were 688,869 admissions charged to influenza for the year, or 20 per cent. of the command. This record does not represent the full incidence of the disease during this period.

10. There were 47,384 deaths from all diseases for the year 1918, of which 23,007 were attributed to influenza. In addition, 16,364 were due to pneumonia infections, bronchitis and pleurisy, many of which, it is certain, should have been charged to influenza, making a total of 39,371 due to acute respiratory diseases, or 82 per cent.

of the total deaths from disease for the year. Influenza with its complications is charged with 48.5 per cent. of the total deaths from disease for the year.

11. Influenza was more prevalent among white troops than among colored troops.

12. White soldiers from the South had much higher admission and death-rates for influenza than white soldiers from other sections. The lowest rates for these diseases were among soldiers from the Pacific Coast and Rocky Mountain states.

13. The negroes stationed in the United States had lower admission rates for influenza than the whites for the country at large, and much lower for these diseases than the whites from the South.

14. The incidence rate for all forms of pneumonia, both primary and secondary, was nearly three times as high for the colored as for the whites for the entire country.

15. The death-rate for all pneumonic infections was more than twice as high for colored troops as for whites.

16. The case mortality for all pneumonic infections for the colored was about 20 per cent. lower than for the whites.

During the months of October, November, and December, 1918 maratime quarantine had the effect of holding at the sea frontier the intensely infective form of influenza prevalent in all other countries. In January, 1919 a milder form of influenza gained entrance. A review of the ship epidemics[1] demonstrated that inhalation of antiseptic sprays, inoculation, and isolation would not of themselves stop an epidemic. The factor which determined the course of the epidemic was the inherent nature and vigor of the infecting agent. Vaccination with a composite vaccine gave such satisfactory results as a prophylactic that it was prepared on an extensive scale. The vaccine was prepared in two concentrations:

[1] Cherry, *Commonwealth of Australia, Service Publication No. 18.* Melbourne, 1919, pp. 1–176.

	"A."	"B."
B. influenzæ	25,000,000	125,000,000
M. catarrhalis	25,000,000	125,000,000
Pneumococcus	10,000,000	50,000,000
Streptococcus	10,000,000	50,000,000
A Gram-positive diplococcus isolated from all cases	10,000,000	50,000,000

The use of the vaccine was associated with a fall in the incidence and case mortality of the disease, the ratio of deaths in the inoculated and uninoculated groups being as 5 to 24. Where the vaccine was used as a method of treatment the good effect on the clinical course of the cases so treated was unmistakable.

Cadnam[1] used a mixed vaccine for prophylaxis against influenza. The vaccine contained in each cubic centimeter the following:

Streptococcus	1,800,000,000
Pneumococcus	900,000,000
Influenza bacillus	1,200,000,000

Two per cent. tricresol was added and the mixture heated to 60° C. for one-half hour. The dose administered was 0.5 c.c. Two doses were given with a seven-day interval. Of 7600 soldiers in the district at the time, 4842 were inoculated. The results were as follows:

	Admissions.	Pneumonia.	Per cent.	Deaths.	Per cent.
Inoculated	282	17	6.05	5	1.7
Uninoculated	238	41	17.10	17	7.1

Of the 5 inoculated soldiers that died 3 had received their first inoculation on the day of admission. There were no deaths among those admitted to the hospital subsequent to the second inoculation. The disease and the complications were not as severe in the inoculated as among the uninoculated, and the average stay in the hospital was twice as long for the uninoculated.

About 700,000 doses of the vaccine were used among the civil population of Winnipeg and throughout the West; 28,815 persons received one dose and 24,184 re-

[1] *Canad. Med. Assoc. Jour.*, 1919, ix, 519.

ceived two doses of the vaccine, a total of 52,999 persons. The results reported were as follows:

Incidence of disease.	After first dose	Per cent.	After second dose.	Per cent.	Total.	Per cent.
Influenza....	2843	9.80	2360	9.70	5203	9.80
Pneumonia ..	177	0.61	123	0.50	300	0.56
Deaths......	01	0.21	24	0.09	85	0.16

Reports were received from physicians concerning the incidence of disease among 85,941 of uninoculated persons. These results were as follows:

	Cases.	Per cent.
Influenza......................	21,285	24.80
Pneumonia.....................	1,869	2.10
Deaths........................	563	0.66

Anthrax.—The repeated occurrence of anthrax infection through the use of hair and bristles, especially when made up into shaving brushes, emphasizes the necessity of sterilizing hair, bristles, hides, and articles made from these. This can be accomplished either by the use of chemical disinfectants or by boiling the finished article, or heating in a steam sterilizer at 115° C.; 10 per cent. formaldehyd solution is serviceable for many articles.

Trench Fever.—This disease occurred among the soldiers in the trenches, and hence its name. It was determined that the virus of the disease is contained in the blood of infected persons and that it is transferred from the sick to the well by the body louse. The virus is transmitted by the louse in sucking blood and also by louse feces gaining access to abrasions. The virus is given off by the patient in the urine and possibly in the sputum. The urine and sputum of patients must be regarded as infectious and disinfected to prevent the dissemination of the disease by these agents. The exact nature of the virus is undetermined. The disease can be controlled by eradicating the body louse.

Typhus Fever.—This disease is still a serious scourge in the Balkans and in Poland, though it is also encoun-

tered in many of the other countries of Europe, Asia, Africa, South America, and in North America, especially in Mexico. No cases have been encountered in the United States for several years, though some years ago it occurred in à mild form in New York City and was known under the name of "Brill's disease."

Typhus fever is of undetermined cause, though the infection is transferred from the sick to the well by the body louse. A successful campaign against typhus fever must include the eradication of the body louse. By disinfection of the body and clothing of persons crossing the border from Mexico it has been possible to prevent the introduction of the disease into the United States.

Trachoma occurs to a considerable extent in certain districts of Kentucky, West Virginia, Tennessee, and Ohio. It is prevalent especially in Cuyahoga, Mahoning, Hamilton, Summit, Franklin, Scioto, and Butler counties, but it is found in practically every county of the state of Ohio. The disease occurs among the workmen in the great industrial centers as well as in children in the public schools.

The U. S. Public Health Service has been conducting clinics and hospitals for the treatment of the disease in Jackson, London, Greenville, Pikeville, Coeburn, Ky., and Tazewell, Tenn. During the year 1919 the hospitals of the service treated 4004 cases of trachoma, Hospitals and clinics have also been opened in Florida, Alabama, North Carolina, Texas, North Dakota, and Montana. In the immediate future the Public Health Service will also engage in field work in Ohio.

Typhoid fever is generally regarded as an autumnal disease, though it prevails at all seasons of the year. It finds available a greater number of disseminating agencies during the summer and early fall in the greater prevalence of flies at that season, and also the greater amount of traveling by those enjoying a summer vacation.

Typhoid fever is disseminated in water; contaminated food, especially dairy products; oysters; flies, and by direct contact. The disease has been controlled in large cities by purification of the water-supplies, by the sanitary disposal of sewage and of garbage, by the pasteurization of the milk-supply, by campaigns against flies, by the disinfection of the excreta of patients, and by the use of typhoid vaccine to immunize healthy persons.

No person convalescing from typhoid fever should be released from isolation until three negative cultures have been obtained of both urine and feces at intervals of five days. This is necessary in order to prevent the release of persons that have become carriers of the bacillus.

What has been said concerning typhoid fever will also apply to paratyphoid fever. Typhoid and paratyphoid fevers can be prevented by the vaccination of healthy persons. These immunizations should be repeated about every two years.

Dysentery.—The dissemination of dysentery is similar in every respect to that of typhoid and paratyphoid fever. The preventive measures are also similar.

Cholera.—The dissemination of cholera is similar to that seen in typhoid fever and in dysentery, and the preventive measures are also similar. Cholera vaccine has been in successful use for a number of years.

Transmission of Relapsing Fever.—For a long time it was believed, on the basis of the investigations of Tictin, that the bedbug transmitted relapsing fever. This assumption was not substantiated by animal experiments. Mackie[1] was the first to direct attention to the rôle of Pediculus vestimenti on the basis of epidemiological observations in an outbreak of relapsing fever in a small school. On microscopic examination of clothes lice he found 14 per cent. of those secured from boys and 2.7 per cent. of those secured from girls to be infected with spirochætes. Female lice were more commonly infected. The stomach and intestines contained spiro-

[1] *The Lancet*, 1907.

chætes, and the fluid expressed from the mouth contained a great many. He concluded, therefore, that infection occurred in the act of sucking blood. Sergent and Foley[1] showed that in the Algerian form of relapsing fever the disease could be transmitted to human beings and to monkeys with crushed lice five to six days after these had become infected.

Nicolle, Blaizot, and Conseil,[2] in Tunis, showed that Pediculus vestimenti as well as Pediculus capitis carried the disease. Five to six hours after sucking blood the spirochætes disappeared from the intestines of the lice. After eight days the spirochætes reappeared, and remained virulent until the nineteenth day. The percentage of infective lice was 17.57 per cent. Toyoda[3] found that the spirochætes soon disappeared from the intestine, but about the seventh day made their appearance in the head in the vicinity of glandular organs, and in consequence believes it is quite probable that infection occurs in the act of biting.

The African form of relapsing fever is known to be disseminated by a tick, Ornithodorus moubata. The relapsing fever of North America and the relapsing fever of India are distinct from the European and the African types of the disease, and are believed to be transmitted by blood-sucking insects.

The spirochetes of the four types of relapsing fever have different characters, so that they may be distinguished from each other as follows:

European—Spirochæta recurrentis, Lebert, 1874.
African—Spirochæta duttoni, Novy and Knapp, 1906.
American—Spirochæta novyi, Shellack, 1907.
Indian—Spirochæta carteri, Manson, 1907.

Prevention of Malaria.—As was shown by Smith and Kilborne, and substantiated by Koch, certain insects are the carriers of the infective organisms of Texas cattle fever. Manson and Ross have demonstrated

[1] *Bull. Soc. de pathol. Exot.*, 1911.
[2] *Arch. de l'Inst. Pasteur de Tunis*, 1912.
[3] *Zeitschr. s. Pyg.*, vol. lxxvi, p. 313.

that a certain kind of mosquito is the carrier of infection for birds, and that other species of mosquitoes are the carriers of the malarial infection for human beings. They found the evolution cycles of the resistant form of the malaria parasites in the bodies of Anopheles, while in man the parasites assume the asporulation phase, so that man is merely the temporary host of the parasites. According to Mattei,[1] the evolution cycle of the malaria parasites consists, therefore, of a chain of two rings—man and the mosquito—man infected with malaria infects healthy mosquitoes, and the infected mosquitoes infect healthy persons, thus completing the cycle.

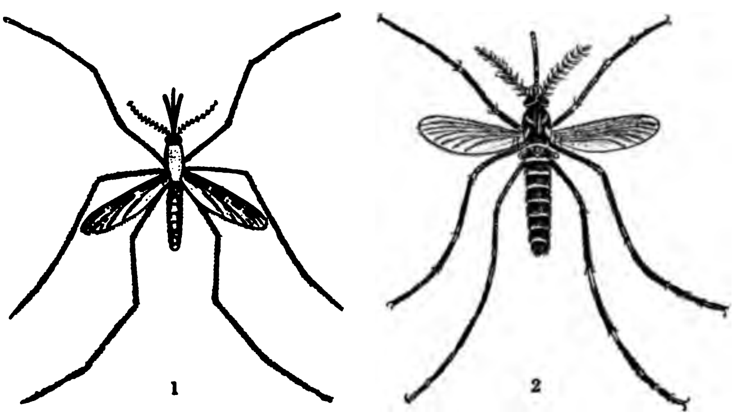


FIG. 59.—Mosquitoes instrumental in the dissemination of malarial and yellow fevers: 1, Anopheles; 2, Stegomyia.

The species of mosquito which appears to be principally, if not entirely, concerned in carrying malarial infection to man is the Anopheles. Mattei found that protection against mosquitoes by means of wire screens at windows and doors, and mosquito-netting, served to protect against malaria while sojourning in malarious localities. Sambon and Low, of the London School of Tropical Medicine, demonstrated the same thing while living in notoriously malarious localities in Italy. Dr. Elliott, a member of the Liverpool Expedition to

[1] *Centralbl. f. Bacteriologie*, Bd. xxviii, S. 189.

West Africa, and Prof. Grassi,[1] the leader of an Italian expedition to the plains of Capaccio, Italy, report similar results. Wire screens and mosquito-netting were found to exclude the Anopheles from habitations, but failed to exclude the non-infecting culex.

A. Celli[2] succeeded in limiting the incidence of malaria in the railroad employees of the malarious districts of Italy by protecting the windows with wire screening of 1 to 1.5 square millimeters mesh, attaching automatic locks to the doors, covering the chimneys with wire screening, and whitewashing the walls. In front of the doors was placed an antechamber constructed of wire screening. Those who were obliged to work out-of-doors at night had all exposed portions of the body protected: the head and face by means of a wire mask, and the hands by means of gloves. Of the 207 officials protected in this manner, only 10 contracted malaria, while all unprotected persons in the same locality suffered from the disease.

Manson[3] reports a most interesting experiment demonstrating the direct relation of mosquitoes to malarial infection. He reports the successful inoculation in London with malaria of an uninfected individual by means of mosquitoes brought from Italy. The subject, Dr. Manson's son, submitted on three occasions to the bites of the imported and infected mosquitoes, with the result that within a few days after the third inoculation symptoms of tertian malarial fever appeared, together with the presence of the corresponding parasites in the blood. Relief was promptly afforded by the administration of quinin. Similar observations are said to have been made in New York City on a patient in Bellevue Hospital, who volunteered for the purpose of the experiment.

The Koch method of preventing malaria consists in the removal of the parasites from the blood of those suffering from the infection; in the prevention of infection of mosquitoes by making it possible for them to bite

[1] *Centralbl. f. Bacteriologie*, Bd. xxviii, S. 535.
[2] *Ibid.*, Bd. xxviii, S. 696.
[3] *British Medical Journal*, September 29, 1900, p. 949.

those carrying the parasites in their blood. Adults that are found to be infected with malarial parasites are each given 1 gram of quinin in 10 per cent. watery solution for four to six days; children smaller quantities. Subsequently they are given each week 2 grams in solution on two successive days, and this treatment is continued for two to three months.

In a notoriously malarious region it is impossible to examine the blood of the entire population, and hence it is not possible to prevent the infection of mosquitoes and the dissemination of the disease to healthy persons. For this reason it is always advisable to resort also to the plan advocated by Ross, that of the destruction of mosquitoes and the elimination of their breeding-places. The combination of the Ross and Koch methods in Cuba and the Canal Zone has been found more efficacious than is either method when used separately.

Immunity against Malaria.—Koch believed that long-continued residence in a malarious district led to immunity as indicated by the absence of parasites in the blood of adults. This position is disputed by Glogner,[1] who does not regard the absence of parasites in the blood as proof positive of freedom from malaria. He contends that the continued infection of these persons is shown in the marked anemia and enlarged spleens which they present. Glogner does not believe that there is any immunity conferred by an attack of malaria.

Prevention of Yellow Fever.—The theory of the propagation of yellow fever by mosquitoes was advanced by Dr. Carlos J. Finlay, of Havana, as early as 1881. In a preliminary report of the investigations of a commission sent to Cuba by the Surgeon-General of the U. S. Army, to study yellow fever, which Dr. Walter Reed presented before the American Public Health Association at Indianapolis, Ind., October 24, 1900, are brought forward most interesting and important facts with regard to this mode of dissemination of the disease. These investigations by the commission confirm the observations of Dr.

[1] *Virchow's Archiv*, vol. clxii, p. 222.

Henry R. Carter, Surgeon of the Marine-Hospital Service at Orwood and Taylor, Miss., that "the period from the first (infecting) case to the first group of cases infected at these houses (isolated farm-houses) is generally from two to three weeks." After the houses had become infected susceptible individuals thereafter visiting the houses for a few hours fall sick with the disease in the usual period of incubation,—one to seven days.[1]

Other observations, made by Reed and his assistants in Cuba, confirmed Dr. Carter's conclusions, "thus pointing, as it seemed to us, to the presence of an intermediate host, such as the mosquito, which, having taken the parasite into its stomach, soon after the entrance of the patient into the non-infected house, was able after a certain interval to convey the infecting agent to other individuals, thereby converting the non-infected house into an 'infected' house. This interval would appear to be from nine to sixteen days (allowing for the period of incubation), which agrees fairly closely with the time required for the passage of the parasite from the stomach of the mosquito to its salivary galnds."

The species of mosquito which serves as the intermediate host in yellow fever has been identified by L. O. Howard, Ph.D., Entomologist, Department of Agriculture, Washington, D. C.[2]

Reed and his assistants failed to find any specific micro-organisms in the blood of yellow-fever patients, nor in the cadavers of yellow-fever subjects. They were able, however, to inoculate the disease successfully by means of infected mosquitoes in non-immune subjects after ten to twelve days had elapsed from the time of sucking the blood of yellow-fever patients; the period of incubation was the usual one, and the symptoms developed were typical.

These facts tend to explain many of the points that were obscure heretofore; notably, the fact that frost arrests the spread of yellow fever. This fact is, no

[1] *Philadelphia Medical Journal*, October 27, 1900.

[2] *Medical Record*, vol. lv, No. 21, May 27, 1799.

doubt, due to the destruction of infected mosquitoes by the frost. The immunity of the pine belt of the Southern States may also be explained by the fact that in these regions the conditions of life and multiplication are unfavorable to mosquitoes.

Extermination of the mosquito in Havana resulted in the virtual eradication of yellow fever. In an official report Major W. C. Gorgas, of the Army Medical Department, who was chief sanitary officer of General Wood's staff, says:

"We commence June with the city free from yellow fever, no cases being on hand. This is probably the first time Havana has ever entered June free from yellow fever. April and May also commenced in the same way.

"Formerly we paid no particular attention to the mosquito, merely disinfecting for yellow fever, as we do for other infectious diseases. The amount of sanitary work done formerly continues, but most of our attention is now being paid to the destruction of mosquitoes.

"The suburbs and the small streams in the suburbs have been thoroughly cleaned out, and pools have been oiled and drained. The Mayor has issued an order prohibiting the keeping of standing water within the city limits unless made mosquito-proof. This is being enforced, and all standing water found not protected is emptied and the owner fined."

The results of regulations instituted in Cuba by the military authorities of the United States for the control of yellow fever have been most gratifying. Aside from a diminution of the incidence of malaria, there was a rapid diminution of the death-rate from yellow fever. While the average death-rate from yellow fever had been 467 annually, the number fell, soon after the introduction of the preventive regulations, to 5 in 1901, and since September 28, 1901, there has been no case of yellow fever in Havana.

Noguchi[1] has found a spiral organism in the blood of yellow fever patients which he has named Leptospira

[1] *Jour. Exp. Med.*, xxx., pp. 13–29, 1919.

icteroides. This organism is transmissible to monkeys and guinea-pigs by injecting the blood of patients taken during the first week of the disease.

The immunization of animals for the preparation of a serum to be used in the treatment of yellow fever is now under investigation.

The Killing of Flies.—It has been well established that flies serve as disseminators of a number of diseases by conveying the bacteria on the surface of their bodies to food materials. Campaigns against flies have been organized in many localities. These efforts are directed against the breeding of flies and the killing of adult flies.

Flies breed in horse manure and other refuse materials, as garbage, waste paper, and decomposing vegetable matter. All manure and sweepings from stables should be removed at frequent intervals so as to prevent flies from breeding in the materials. Cleanliness about stables, backyards, outhouses, and alleys will aid greatly in reducing the fly nuisance.

When manure cannot be removed from the premises each day, it should be stored in such a way as to prevent flies from breeding in it. This can be done by mixing chemical substances, as lime or ferrous sulphate, with the manure. This, however, is an expensive measure.

A better method is to attack the flies at the most vulnerable point in their development. The female fly lays eggs in manure. Under favorable conditions these hatch in a day and are now the well-known maggot. The maggot burrows downward in the manure and seeks a dark and dry place for the next stage in its development—the pupa stage. If we contrive to prevent the maggots from developing into pupæ we can break the cycle in the development of the fly. The simplest device to accomplish this is to spread the manure on a trellis of iron rails raised a foot or more above the ground. If the space beneath the trellis is excavated and filled wit water the maggots will fall into the water and drow

when they burrow downward to pupate. The water in the excavation should be covered with a film of oil to prevent mosquitoes from breeding in it.

When flies congregate on the exterior of buildings or have gained access to the buildings an effort should be made to kill them. Applying a torch to the outside of screened windows and doors on which flies have settled will serve to scorch their wings and they may then be swept up and burned. The same method may be practised indoors when large numbers of flies have settled on ceilings. Spraying insect powder into a room, such as pyrethrum powder, will stupefy the flies and they may then be swept up from the floor and burned.

The common stable fly, Stomoxys calcitrans, has been regarded as a probable disseminator of poliomyelitis. In the absence of complete knowledge it will be best to make every effort to control the breeding of these flies in horse manure and to prevent the entrance of these flies into houses.

The safest and most efficient fly poisons for household use are a 1 per cent. solution of formaldehyd or a 1 per cent. solution of sodium salicylate. Neither of these solutions is highly poisonous to children and can cause no fatal poisoning to anyone drinking a small quantity of either solution.

The Killing of Mosquitoes.—A campaign against mosquitoes must be conducted along several lines. By far the most effective method of eradicating mosquitoes is to prevent them from breeding by draining marshy ground; by general cleaning, so as to remove all small receptacles in which water may collect, as tin cans, empty bottles, rain barrels; by screening cisterns containing water; and by covering the surface of standing water with a layer of petroleum.

Adult mosquitoes should be excluded from houses by appropriate screening of all doors, windows, and other openings through which they could enter. Mosquitoes that have entered the house should be killed by fumi-

gating, that is, by burning pyrethrum powder. This stupefies the mosquitoes and they fall to the floor and should be swept up and removed.

The relation of marshy ground to yellow fever is probably less direct than that of its relation to malaria, since the Stegomyia appears to breed in water-tanks and places of that character rather than in marshes, as is the case with the Anopheles. The experience of the military authorities of the United States during the occupation of Cuba demonstrated that general hygienic measures along with the drainage of the marshes had only a moderate influence in reducing the incidence of yellow fever during the first year of the occupation. During the second year, when, in addition to this, energetic measures were employed to eradicate the mosquitoes, the influence upon the incidence of yellow fever was most striking, and with the continuation of the measures it has continued so up to the present time.

During the experiments with petroleum it was found that 5 c.c. per square meter of water surface killed all mosquito larvæ. It was not found necessary to renew the kerosene upon the surface oftener than once in fourteen days.

Destruction of Vermin.—Vermin of other sorts than mosquitoes transmit disease. Rats are known to carry the plague from ships; flies have carried tuberculosis and typhoid; bedbugs and fleas are considered dangerous; lice carry typhus, relapsing, and trench fever.

Lice, especially Pediculus vestimenti, carry infection. This species of louse lives in clothing next to the body surface and gets its nutrition by sucking the blood of the host. They feed about three times a day and die in a few days if deprived of food. They do not leave the clothing to feed, but remain attached thereto by their hind legs and swing out from their habitat and support themselves on body hair by their front legs while feeding.

Removing the infected clothing and airing it for several days will kill the lice. Placing the infected clothing in a

chamber and subjecting to superheated steam will kill the lice. Petroleum kills lice and their eggs.

Bedbugs are a nuisance, and because they suck blood they are potentially dangerous. Beds, bedding, and the cracks in the woodwork of infested rooms should be treated with petroleum to which 3 per cent. of carbolic acid has been added. It is best to treat an infested room at intervals of a week until all bedbugs have been killed.

Dog and cat fleas are a source of great annoyance. The flea breeds in rags and in dust, in cracks of the floor, and in carpets. Sprinkling the floor with naphtha and closing the room overnight will serve to kill fleas. This process must be repeated from time to time in houses where pet dogs and cats are kept.

The **extermination of rats,** because they are the carriers of plague-infection, has become the duty of all civilized governments.

When plague is suspected in a community it will be of great importance to know whether the infection prevails among rats. All rats caught in traps, as well as all rats killed by poison, should be sent to the laboratory for examination.

The rats in a building are exterminated by using poison. Bacon, bread, or grain may be used to carry the poison. Rats may be poisoned in burrows by using carbon bisulphid. If the building can be closed up sufficiently sulphur fumigation should be employed.

In order to keep rats out of buildings the foundations and walls must be made rat-proof. Concrete floors and foundation walls built up with cement will serve the purpose. The measures employed involve the razing of frame structures, replacing wooden floors with concrete, the use of metal lath wherever practicable, and reinforcing double floors with wire netting.

It is the rat flea, Pulex cheops, which carries the plague bacillus from infected rats to healthy rats and to human beings. The rat flea does not ordinarily feed on human beings. When, however, its natural host is not

available it attacks human beings. This explains the fact that epidemics of plague in human beings are frequently preceded by fatal disease among rats.

Relation of Insects to the Spread of Disease.—Within recent years we have come to regard many of the common insect pests with suspicion. This is especially true since the discovery by Ross that the mosquito plays the part of definitive host for the parasite of malaria. The earliest positive demonstration of the instrumentality of insects in the dissemination of disease was made by Smith and Kilbourne. They demonstrated that the tick—Boöphilus bovis—infesting the cattle of the Southern States is instrumental in disseminating the disease Texas fever from sick cattle to the well. Within the last few years a number of other diseases have been found to be disseminated, wholly or in part, through the agency of insects. The relation of insects to the spread of disease may be divided into several classes according to the nature of the organisms and the mode of transmission.

1. Insects may convey pathogenic bacteria on their bodies by coming in contact with infective materials, as tubercular sputum, typhoid, dysentery, or cholera stools. Bacteria may be conveyed considerable distances and then deposited on food-materials, and thus form a new focus of infection. The insect which is probably most frequently the disseminating agent of such diseases is the common house-fly—Musca domestica.

An epidemic of typhoid fever in Chicago during the summer of 1902 was most severe in one of the wards of that city. In this ward, containing one-thirty-sixth of the population of the city, there occurred over one-seventh of the deaths from this disease. The epidemic could not be attributed to the character of the food or to the water-supply, as these did not differ in any respect from the supplies of neighboring wards. An examination of the sewerage of the ward revealed the fact that many of the sewers were too small to carry the sewage. Only 48 per cent. of the houses had sanitary plumbing, while

7 per cent. had defective plumbing, 22 per cent. had water-closets with intermittent water-supply, and 11 per cent. had privies with no sewer connections. Flies caught in two undrained privies, on the fences of two yards, on the walls of two houses, and in the room of a typhoid patient were inoculated into eighteen tubes, and from five of these tubes the typhoid bacillus was isolated. It is evident that this epidemic was brought about by the dissemination of the infectious material by flies.

Roaches may also become agents in disseminating typhoid, dysentery, and cholera by coming into contact with infective material in drains and sewers and subsequently carrying the infectious materials on their bodies to food-materials.

2. Flies may carry tubercle bacilli within their bodies when they are permitted to feed on tubercular sputum. Live tubercle bacilli have been obtained from the feces of flies fed on tubercular sputum. Consequently the feces of flies may be a source of danger. Flies may also serve to carry, in a similar manner, the micro-organisms of a number of other infectious diseases, as diphtheria, pneumonia, erysipelas, suppuration, and possibly of small-pox, though we have as yet no positive proof of the conveyance of small-pox in this manner. Dr. Ficker[1] has found that flies fed on typhoid cultures give off the bacilli twenty-three days after infection. Typhoid bacilli were found in the intestine nine days after feeding on typhoid materials.

3. Suctorial insects, by sucking the blood of persons or animals containing certain bacteria or animal parasites, may transmit these organisms by means of the proboscis to healthy persons or animals. Gad-flies or horse-flies may carry anthrax bacilli in this manner and infect healthy persons or animals. The common bedbug is believed to be instrumental in disseminating the parasite of relapsing fever in a similar manner. The recent studies by Toyoda[2] bring strong evidence that the

[1] *Arch. f. Hygiene*, Bd. xlvi., S. 274.

[2] *Zeitschr. für Hygiene*, Bd. lxvii., 1913, p. 313.

clothes louse, Pediculus vestimenti, is the carrier of the spirochete of relapsing fever, but he could find no evidence that the bedbug could carry the organism. The spirochetes undergo multiplication in the body of the louse, and are later found in the head in the vicinity of the glandular organs. Toyoda believes the louse to be infectious seven days after taking the blood of an infected person. Typhus fever is also disseminated by biting insects, and the clothes louse is the carrier of this disease.

Trench fever has also been found to be disseminated, at least most frequently, by the body louse. The louse usually conveys the virus in the act of sucking blood, but its intestinal contents are also infectious. Moreover, the urine, and possibly the sputum, of patients contains the virus of trench fever.

The agency of fleas in the dissemination of bubonic plague has been demonstrated. Gauthier[1] shows that fleas transmit plague from rat to rat. Fleas taken from a living infected rat caused plague in nine of ten rats. The fleas of these animals were also found to bite human beings, and Gauthier therefore concludes that the connection between the presence of infected rats in a district and the sufferers from plague is represented by these insects. Dr. Zirolia[2] found Bacterium pestis in fleas fed on infected mice. These bacilli were found to be virulent seven to eight days after infection. The bacilli were also demonstrated in the feces. The work of the English Plague Commission[3] leaves no doubt that this is the mode of dissemination of the disease from infected to healthy rats, and the dissemination of the disease to human beings occurs through the bite of infected rat fleas. The flea which is found most commonly on rats in warm countries is Pulex cheops. This flea occurs on both Mus rattus and Mus decumanus. The rat flea in northern countries, where observations

[1] *Bull. de l'Acad. de Méd.*, December 16, 1902.
[2] *Centralbl. f. Bacteriologie*, Bd. xxxi., S. 87.
[3] *Jour. of Hygiene*, March, 1908.

have been made, is Ceratophyllus fasciatus. This flea is also found on the common house mouse, Mus musculus, but less commonly than Ctenopsylla musculi. The flea which is most likely to harbor on human beings is Pulex irritans, though Pulex cheops, the common rat flea, will also bite human beings when its natural host is absent.

Fleas are instrumental in carrying trypanosomes to rats. Trypanosomes have also been found in the stomachs of lice feeding on the blood of infected animals. In Africa trypanosomes are transmitted to horses, cows, sheep, and dogs through the bite of the tsetse fly, Glossina morsitans. Sleeping sickness, a trypanosomiasis in human beings prevalent in Africa, is transmitted by another species of tsetse fly—Glossina palpalis.

4. The transmission of the malarial and yellow-fever parasites to man, as well as the transmission of similar parasites to birds, through the agency of certain species of mosquitoes, is now well established. In the transmission of these diseases the insects are not merely the carriers of the parasites, but also serve the important function of hosts for the parasites in that a certain phase of the life-cycle of the parasite is passed in the bodies of these insects. Without either man or the specific mosquito the malarial and yellow-fever parasites would perish, as it is believed that both are necessary for the completion of the life-cycles of the parasites. The Anopheles is the species of mosquito instrumental in the transmission of malaria, while the Stegomyia is the species instrumental in the transmission of yellow fever. These insects suck the blood of patients suffering from these diseases, and then the fecundated female elements penetrate the wall of the stomach of the mosquito and become encysted. After maturation of the sporocysts they rupture into the body cavity, whence the young parasites find their way into the salivary glands of the mosquito and are then projected through the proboscis into the tissues of healthy persons during the act of sucking blood. In the transmission of parasites similar in nature

to the malarial organism from diseased to healthy birds—sparrows, canaries, crows, buzzards, etc.—it is believed that the common Culex variety of mosquito is the disseminating agent. In the diseases of birds the mosquito plays the same part as in the transmission of malaria and yellow fever in that the parasites undergo one phase of their life-cycle in the bodies of the mosquitoes. The conditions necessary for the occurrence of malaria or yellow fever in a community are the following: (*a*) The primary existence or importation of a case of the particular disease; (*b*) the presence of the particular genus of mosquitoes; (*c*) the infection of the mosquitoes by sucking the blood of the patient; (*d*) the presence of non-immune persons in the community to which the infected mosquitoes may transmit the disease after the lapse of time necessary for the maturation of the young parasites in the body of the mosquito; (*e*) the continuance of the epidemic subsequent to the occurrence of secondary cases requires suitable climatic and telluric conditions for the breeding of the mosquitoes; and (*f*) suitable temperature for development of the zygote in the stomach of the mosquito.

The prevention of the dissemination of either malaria or yellow fever requires observation of the following conditions: (*a*) It is necessary to prevent mosquitoes from gaining access to patients suffering from the disease by suitable screening, because non-infected mosquitoes cannot transmit the disease; (*b*) the protection of healthy persons from mosquito-bites; in this manner they can be kept free from the disease even though infected mosquitoes exist in the community; (*c*) the adoption of measures for the destruction of mosquitoes in all stages of their development—*i. e.*, draining all marshy places, pouring oil on all stagnant waters that cannot be drained, protecting water-tanks, etc., so as to prevent mosquitoes from gaining access thereto; destruction of adult mosquitoes in houses by means of insecticides, as petroleum, pyrethrum powder, or sulphur dioxid gas.

The transmission of filaria by means of mosquitoes

presents certain phases which are similar to those appertaining to the transmission of malaria and yellow fever. The parasite is taken into the stomach of the mosquito, and transmission to other individuals takes place after it has undergone a certain phase of its development in the body of the mosquito. The young parasites are lodged in the sublingual region at the root of the proboscis, whence they find their way into the saliva and are transmitted in the act of biting. Both Culex and Anopheles are believed to be instrumental in the transmission of filaria.

Culex fatigans is now regarded as the transmitting agent of the virus of dengue, though no organism has been demonstrated.

5. It is regarded as a proved fact that typhus fever is disseminated by the clothes louse, Pediculus vestimenti, and in efforts to eradicate typhus fever our chief effort should be directed toward the removal of lice from the entire population of an infected district. This is accomplished by sending disinfecting trains of cars to the infected area and disinfecting the bodies and the clothing of all the inhabitants.

6. Still another manner in which insects transmit disease is that of the transmission of Texas cattle fever by the cattle-tick—Boöphilus bovis. This mode of transmission differs from those already considered in that the fecundated female tick sucks the blood of infected cattle and transmits the parasite to her eggs, and the young ticks in turn transmit the parasite to healthy cattle while sucking their blood. Two generations of ticks are necessary for the transmission of the disease from sick to healthy cattle. The exact manner of the transmission of the parasite from the infected tick to the egg and offspring has not been demonstrated.

A tick—Dermacentor venestus—is instrumental in the transmission of the "spotted fever" of the Rocky Mountain regions. Another tick—Ornithodorus moubata—is instrumental in the transmission of African tick fever.

Remedies for Fleas.—The subject of domestic pests has been fully treated in publications of the Division of Entomology of the Department of Agriculture, and the work of the Division has been supplemented by interesting experiments along the same line by several of the State Experiment Stations. Especially valuable results have recently been obtained in experiments with remedies for the extermination of fleas.

At times fleas, especially the dog- and cat-flea, become one of the most troublesome of household pests. Numerous remedies have been recommended for ridding houses and animal pets of these pests, but these remedies have not proved effective under all circumstances. The Division of Entomology recommends thorough sweeping and cleaning of floors and walls, the disuse of carpets and mattings and their replacement with rugs, which are to be removed and beaten at frequent intervals. It is also recommended that infested carpets and other such objects be dusted with pyrethrum powder or sprinkled with naphtha. Failing in these measures, the removal of carpets and thorough scrubbing with hot soapsuds are recommended.

In some experiments made in Scotland by R. S. MacDougall it was found desirable to cleanse dog-kennels with lime-wash, to wash dogs and cats with soapsuds, and then sprinkle them thoroughly with pyrethrum powder. The use of creolinated water in a 10 per cent. solution was also found effective in ridding houses of fleas and in destroying these insects upon dogs. In some parts of Mexico, according to MacDougall, brooms are made of Asclepias curassivica, a kind of milk-weed, and walls and floors of infested houses are swept with these brooms. The odor of this plant when thus utilized has been found to check the spread of the flea nuisance in houses.

At the Vermont Experiment Station satisfactory results were obtained by sprinkling infested animals and kennels with kerosene emulsion, but this remedy is not applicable in households on account of the disagreeable odor

and other effects of kerosene. At the Michigan Experiment Station pyrethrum gave excellent results in ridding houses of fleas. This remedy, however, has not always proved effective, and in some instances was apparently without effect.

In experiments at the New Hampshire Experiment Station it was found that creolin was the most satisfactory remedy. This may be used in a diluted form as a disinfectant, deodorant, insecticide, and repellant. It was found that a 3 per cent. solution was sufficiently strong for ordinary purposes. Infested dogs and cats may be thoroughly washed with this mixture, which may be made slightly weaker for cats on account of the greater sensitiveness of the fur of this animal. The animals may also be dipped in the solution. Commercial creolin may be purchased at drug-stores for about 25 cents a pint. A 3 per cent. mixture with water may be made by adding 4 teaspoonfuls of creolin to a quart of water or 4 tablespoonfuls to a gallon. A 2 per cent. solution is obtained by adding 2 teaspoonfuls to the quart or 2 tablespoonfuls to the gallon of water. When thoroughly shaken, the mixture is ready for use. The mixture may be applied to the animal with the hands or a brush, or, as already suggested, the animal may be submerged in the solution for about five minutes. The animal requires no further care or treatment after the application. This treatment not only destroys the fleas, but also serves as a deodorant.

In treating floors it is recommended that all unnecessary objects be removed, and that cracks and crevices should be scrubbed with a 5 per cent. solution of creolin. The bedding of animal pets infested with fleas should be thoroughly saturated from time to time with a 5 per cent. solution of creolin.

Two other remedies which are quite effective against fleas have been recommended with some reservation, but these remedies are perhaps too dangerous for general use in households. Reference is had to fumigation with carbon disulphid and hydrocyanic acid.

The above-mentioned remedies include nearly all the substances which have been found effective in destroying fleas. In combating these insects, however, it should always be remembered, as the Division of Entomology of the Department of Agriculture points out, that the infestation of houses is due to the presence of flea-infested dogs or cats, which are allowed to occupy some portion of the house during a part or all the time. Fleas normally live as parasites upon the animals which they infest or upon man, but eggs which are laid by the parasitic adult insects may fall upon the floor or the carpets of houses, and after hatching, may live for an indefinite period upon the dust which accumulates under carpets and in the cracks of floors. In ridding a house of fleas attention should, therefore, be directed first to treatment of the dogs or cats from which infestation originates. This treatment, if done in a thorough manner, will rid the animal pets of fleas and will prevent re-infestation of the house after a thorough application of the insecticides.

Human Carriers of Disease.—Many diseases are disseminated by persons that are apparently healthy and have not recently been in contact with patients. These persons carry, sometimes for years, the virulent micro-organisms and transmit them to susceptible persons by direct or indirect contact.

Aside from the fact that most persons carry the pyogenic staphylococci on their skin and mucous membranes, and that many persons carry virulent streptococci, pneumococci, and influenza bacilli in their upper respiratory tracts, these individuals are not generally regarded as carriers. Potentially all these persons are carriers, and should be freed from the infecting organisms. When that is done we shall see the decline of the infections caused by these organisms, now so prevalent.

Persons carrying the diphtheria bacillus and the meningococcus in their respiratory tract are now treated as carriers and are segregated until bacteriologic examination fails to show the organisms. This procedure is of

the greatest value in combating diphtheria and meningitis.

The diseases of the intestinal tract are very frequently disseminated by carriers. In some instances these carriers have had the infection some years previously and have never become free of the infection. In other instances no definite history of previous infection can be elicited. Typhoid and paratyphoid fever, dysentery, and cholera are frequently disseminated by carriers. The typhoid carriers sometimes show a chronic infection of the gall-bladder or of the kidney, and give off large numbers of the bacilli in the feces or in the urine, depending on the localization of the infection. Wherever found, the carriers of the intestinal diseases should be segregated and treated or their activities controlled so as to prevent them from being a menace to the community. At least these persons can be controlled as to the occupation they follow. They should not be allowed to handle foods that may become contaminated and so start an epidemic.

Animal Parasites.—Animal parasites are living organisms which live in or upon other living organisms for the purpose of obtaining nutrition, and live there either temporarily or permanently. The parasitism is of different forms and various grades in the different parasites, and Leuckart has divided them into two classes—temporary and permanent parasites. Among the temporary parasites may be mentioned the flea (Pulex irritans), the bed-bug (Cimex lectularia), the leech (Hirudo medicinalis), the different species of mosquitoes, as well as others which seek the host merely for the purpose of sucking blood, and depart after having satisfied their hunger. Their entire existence from the egg to the adult stage is passed outside the body of the host. These parasites attack only the surface of the body of the host, and hence have been called epizoa or ectoparasites, though these terms do not apply to the temporary parasites alone.

The permanent parasites pass a portion or even their entire life in or upon the body of the host, so that they obtain lodging as well as nutrition from the affected host. These parasites usually live within the body of the host, principally in those organs which are readily accessible from the outside, as the intestines and their appendages, though others invade the muscles, lymphatic system, circulatory system, bone-marrow, brain, etc.

In many instances it is not possible to demonstrate a definite influence exerted by the parasite upon the host organism. But in other instances the presence of the parasite is manifested by its particular location, the number of parasites, the movements induced, or the nutrition absorbed from the host, in consequence of which they induce more or less marked disturbances of the health of the host, or may even lead to its destruction. Certain of the animal parasites evidently produce poisonous metabolic or excretory products which give rise to definite symptoms. There is evidence to believe that in malaria, yellow fever, trypanosomiasis, and other diseases the grave symptoms produced by the infection are due to poisons generated by the parasites as the result of their development and metabolism.

Protozoa.—The protozoa are unicellular animal organisms which multiply in two ways: sexual and asexual development. The asexual development takes place within the body of the host under favorable conditions, and as a result there may be an enormous increase in the number of individuals. The sexual mode of development serves for the preservation of the species in that it supplies a phase in the life of the parasite when it may be transplanted from one host to another. Most of the protozoa are nourished either by osmosis or by the invagination of small food-particles. One class of the protozoa, the suctoria, possess small suctorial tubes through which they take up their nutrition.

Endameba hystolitica (Loesch).—This parasite was found by Koch and Gaffky in 1883 in Egypt in the intestines of five cases of dysentery that came to autopsy.

Since that time the parasite has been found in all parts of the civilized world, and is regarded as the etiologic factor of tropical dysentery.

This parasite is evidently taken into the system in polluted water, or food that has been grown on soil fertilized with human excrement. The preventive measures which are most serviceable are prompt disinfection of all stools from cases of chronic dysentery, filtration or sterilization of infected water-supplies, and the avoidance of raw food that might possibly be the carrier of the infective agents.

Source of the Endameba and Mode of Infection.—Futcher[1] states that "very little is known regarding the source of the endameba and the mode of infection. We are still absolutely unfamiliar with the life-history of the parasite outside of the body. Inoculation experiments by way of the mouth, with the possible exception of those of Quincke and Roos with the so-called encysted forms, have been entirely negative. It is highly probable that infection takes place by way of the gastro-intestinal tract, and that amebic dysentery is contracted in much the same way that typhoid fever, cholera, and bacillary dysentery are contracted."

The Plasmodium of Malaria.—The plasmodium of malaria belongs in the order Hæmosporidia, class Sporozoa. Three different parasites are recognized: the Plasmodium malariæ, the parasite of quartan, Plasmodium vivax, the parasite of tertian, and Laverania malariæ, the parasite of quotidian fever. Though these three parasites differ in their morphologic and biologic characters, it is believed that each of them finds in the Anopheles its appropriate definitive host in which it undergoes sexual development or sporogony. In man it undergoes the non-sexual development, or schizogony.

Trypanosomiasis.—The occurrence of trypanosomes in human blood was first reported by Dutton.[2] The preva-

[1] Futcher, *Jour. Amer. Med. Assoc.*, 1903, vol. i., p. 480.

[2] *Thompson-Yates Laboratory Reports*, 1902, vol. iv.

lent type of trypanosomiasis infection in Africa is sleeping sickness. The parasite most commonly found in man has been named Trypanosoma gambiense, and is believed to differ from the trypanosomes producing nagana, or tsetse-fly disease of horses, occurring in Zululand and South and West Africa; surra, in India; dourin, in Algiers; mal de Caderas, in South America; and a disease of cattle recently discovered in Pretoria. The experimental evidence at hand indicates that each of the parasites producing these diseases differs in certain morphologic and biologic characters, the most convincing of which is the lack of immunity induced by one parasite against infection by another.

A second type of trypanosome infection in man has been discovered in different parts of Africa, which is due to a parasite that differs morphologically from Trypanosoma gambiense. This new parasite has been named Trypanosoma rhodesiense. It causes a form of sleeping sickness of greater virulence than that due to Trypanosoma gambiense. The investigations that have been made indicate that Trypanosoma rhodesiense is disseminated by Glossina morsitans and not by Glossina palpalis.

A third trypanosome has recently been found in cases of sleeping sickness in Nigeria, which has been named Trypanosoma nigeriense.

Sleeping sickness is stated to have been the cause of 600,000 deaths in central Africa during the past ten years, and hence it is a disease of great importance from a public health standpoint, especially because it tends to extend to new territory as the means of communication become favorable.

Whether the trypanosomes of sleeping sickness undergo some form of development in the body of the fly, or whether they are transmitted directly by means of the infected proboscis, cannot be stated definitely, but the general opinion is that they are transmitted most commonly after undergoing transformation in the body of the fly.

Glossina morsitans also transmits the parasite of a

trypanosomatic infection of horses and wild animals in Africa—namely, Trypanosoma brucei—and morphologically the parasite resembles that of sleeping sickness. There is, however, an important difference between the parasites in that Trypanosoma brucei and Trypanosoma rhodesiense are easily affected by human blood-serum, while Trypanosoma gambiense is not. Several other forms of trypanosomatic infection occur in horses, cattle, sheep, dogs, and birds, which are believed to be transmitted by blood-sucking insects. The trypanosomatic infection seen in rats, due to infection by Trypanosoma lewisi, is believed to be carried from diseased to healthy rats by fleas. McNeal has also found that Trypanosoma lewisi is transmitted from diseased to healthy rats by infected lice. Lice that had been allowed to suck the blood of infected rats had the parasites in their stomachs for some time. He found no evidence that the parasites underwent transformation in the lice.

The parasite of nagana, Trypanosoma brucei, is transmitted through the bite of the tsetse-fly (Glossina morsitans); the parasite of dourin, Trypanosoma rongeti, is transmitted during coition; while nothing definite is known regarding the mode of transmission of Trypanosoma evansi, the parasite of surra; Trypanosoma elmassiani, the parasite of mal de Caderas; nor of Trypanosoma theileri, the parasite occurring in cattle in Pretoria.

Leishmanioses.—A group of diseases occurring in man in the Orient, known under the names kala-azar, Oriental sore, infantile splenic leishmaniosis, is due to a parasite known under the name Leishmania. This parasite was first discovered by J. B. Leishman. Kala-azar is due to a parasite which has been named Leishmania donovani, and prevails in India and Ceylon. Kala-azar is believed to be transmitted by a flea, Pulex serraticeps. Four other species of this parasite cause infection in man: L. furunculosa, L. infantum, L. nilotica, and L. brasiliensis.

Piroplasmoses.—Diseases in which the red blood-corpuscles are invaded by an animal parasite which differs

materially from the parasites of malaria have been discovered in cattle, sheep, dogs, horses, and in man. Because of the peculiar appearance of the parasite of piroplasmoses, the distinctive name has been coined for it. In all of these diseases a certain type of tick has been discovered to be the transmitting agent.

Texas Cattle Fever.—Though not infectious to a marked degree, this disease has an important relation to the subject under discussion. The mode of transmission of Texas cattle fever is of a type entirely different from that seen in any of the diseases discussed. The transmitting agent in this disease is the cattle tick, Boöphilus bovis, as discovered by Theobald Smith in 1891. This insect is believed to be incapable of transmitting the disease directly. The fecundated female tick sucks the blood of infected cattle and then falls to the ground to deposit its eggs. The eggs hatch after twenty to forty-five days, and the young ticks attach themselves to the cattle and carry the infection.

It will be seen that in the transmission of this disease two generations of ticks are requisite to complete the cycle of development of the parasite and permit the dissemination of the disease from infected to healthy cattle.

Although piroplasmoses of cattle are not frequently transmitted to human beings, Lingard has found the Piroplasma bigeminus in a herdsman who was suffering from malaria. He regards it as probable that the tick is capable of transmitting the parasite of cattle fever to individuals that are otherwise debilitated.

Other species of ticks are also believed to be instrumental in the transmission of disease among sheep, dogs, and other animals. None of these diseases is, however, infective to man, so far as known.

Spotted Fever of the Rocky Mountains.—This disease is localized along the foothills of the Rocky Mountains in Montana and Idaho. It is believed to be due to a parasite localized in the red blood-corpuscles of human beings, and which is transmitted by means of a tick, Dermacentor

venustus, infesting the gopher. While certain details of the nature of this disease and the mode of its transmission are still unsettled, it is of importance in this particular, because the evidence seems to indicate a close similarity in the form of the parasite and in the mode of its transmission to that seen in piroplasmoses of the domestic animals.

Wilson and Chowning[1] believe that the parasite is conveyed to man by the bite of ticks, several species of which are found in the infected locality. Though no infected ticks have yet been encountered, there is strong presumptive evidence that they serve as the carriers of the parasite, from the fact that the disease prevails at the season of the year when the ticks are prevalent—that is, from March to July.

Inoculation experiments upon rabbits with the blood of a fatal case were successful, the parasites persisting in the blood of the rabbit for four weeks.

The exact nature of the organism found in the blood of spotted fever patients remains undetermined. Wilson and Chowning believed the parasite to be a hematozoön. This has been contradicted by others.

During the year 1917 56 cases of spotted fever were reported to the Public Health Service from the far western and northwestern states. Thirty-two deaths occurred, giving a fatality rate of 57.14 per cent. The disease occurs in Nevada, Utah, Montana, Wyoming, and California. The disease occurs during the months from April to September, being encountered most frequently in May, June, and July.

Other Diseases in which the Occurrence of Animal Parasites has been Reported.—The most important disease of man which is now regarded as due to animal parasites is *small-pox*. The work of Councilman and his associates presents strong evidence in favor of the parasitic theory of the causation of small-pox. Councilman believes he has demonstrated two life-cycles of the para-

[1] *Jour. Amer. Med. Assoc.*, July 19, 1902.

site, sexual and asexual, the former occurring only in human beings and in monkeys, while the latter occurs in man, as well as in the lower animals (vaccinia). These facts, if correct, indicate that man is the definitive host of the small-pox parasite, and that cattle serve merely as an intermediate host.

Graham[1] presents facts which indicate that the etiologic factor of *dengue* is also an animal parasite. Graham believes that the parasite of dengue is transmitted by a species of mosquito—Culex fatigans. He states that mosquitoes that had bitten a sick person were carried into a locality where there was no case of dengue; two persons bitten by them contracted the disease after the normal incubation period of four to five days respectively; no new cases occurred subsequently in the village. The rôle of the mosquito in the propagation of dengue appears to accord with these facts.

Naturally Graham has sought hematozoa in the blood of the sick. He discovered an endoglobular hematozoön with ameboid movements which he found constantly in blood taken from individuals attacked by a typical form, and where the temperature was above 38° C. (100° F.). Graham's description of the parasite is made solely after examinations in the fresh state; he did not succeed with stained preparations.

Graham endeavored to follow the evolution of his Piroplasma in the blood of mosquitoes; he found that it produced spores, and very soon the walls of the stomach and the salivary glands contained spores. Mrs. Graham was attacked with dengue the third day after having been bitten accidentally by one of these mosquitoes.

A person inoculated with an emulsion of salivary glands from the same mosquitoes had, three days later, a particularly intense attack of dengue.

Helminthiasis.—Infection by different kinds of worms is of less hygienic interest, since most of them occur in more or less isolated localities, or are less generally distributed than some of the *sporozoa*.

[1] *Journal of Tropical Medicine*, 1903, vol. vi.

The larvæ of the trematodes live in water and gain access to food. They are also disseminated by green vegetables grown on soil that has been fertilized with night-soil. Of the nematodes, the larvæ of Uncinaria and Anguillula are disseminated in a similar manner. The larvæ of Filaria medinensis live in Cyclops quadricornis, which is so common in fresh water. It has been determined by Manson that the developmental cycle of Filaria medinensis in the body of Cyclops requires from five to nine weeks, and the cycle in the human being is completed by the next year, when the young cyclops is again at hand to serve as the intermediate host of the parasite.

The mosquito, probably both Culex and Anopheles, serves as the intermediate host of Filaria nocturna. The embryos of the parasite, after reaching the stomach of the mosquito, penetrate into the musculature of the thorax, and thence, after undergoing further development, they pass into the root of the proboscis. When they reach this point, they are injected into the tissues of the person in the act of sucking blood.

The table here given, taken from the paper of Dr. Henry B. Ward,[1] lists all the human parasites of the various groups of worms heretofore recorded, and is based largely on the classification given by Braun.

Parasite.	Found as Human Parasite in		Type of Parasitism.	Recorded frequency as human parasite.
	Stage of Parasite.	Organ of Host.		
Trematoda (flukes)—				
Gastrodiscus hominis	Adult	Colon	Occasional	Twice
Fasciola hepatica	"	Liver	"	Rare
Fasciola angusta	"	(?)	(?)	Once?
Fasciolopsis buski	"	Intestine	Normal	Rare
Fasciolopsis rathouisi	"	"	Occasional	Once
Paragonimus westermanii . . .	"	Lung	Normal	Abundant
Opisthorchis felineus	"	Liver	"	Frequent
Opisthorchis sinensis	"	"	"	"
Opisthorchis noverca	"	"	Occasional (?)	Once
Metorchis truncatus	"	"	Occasional	" (?)
Heterophyes heterophyes . . .	"	Intestine	Normal	Frequent
Dicrocœlium lanceatum . . .	"	Liver	Occasional	Rare
Schistosoma hæmatobium . .	"	Portal vein	Normal	Frequent

? Record open to question.

The occurrence and distribution of the different forms

[1] *Jour. Amer. Med. Assoc.*, September 19, 1903.

Parasite.	Found as Human Parasite in		Type of Parasitism.	Recorded frequency as human parasite.
	Stage of Parasite.	Organ of Host.		
Cestoda (tape-worms)—				
Dibothriocephalus latus	Adult	Intestine	Normal	Abundant
Dibothriocephalus cordatus	"	"	Occasional	Rare
Diplogonoporus grandis	"	"	"	"
Bothriocephalus mansoni	Larva	Connective tissue	"	"
Dipylidium caninum	Adult	Intestine	"	"
Hymenolepis nana	"	"	Normal(?)	Frequent
Hymenolepis diminuta	"	"	Occasional	Rare
Hymenolepis lanceolata	"	"	"	Once
Davainea madagascariensis	"	"	"	Rare
Davainea(?) asiatica	"	"	(?)	Once
Tænia solium	"	"	Normal	Abundant
Cysticercus cellulosæ	Larva	Connective tissue	Occasional	Rare
Tænia saginata	Adult	Intestine	Normal	Abundant
Tænia marginata	Larva	Connective tissue	(?)	Once(?)
Tænia serrata	Adult	Intestine	Occasional	Twice(?)
Tænia africana	"	"	Normal(?)	Once
Tænia confusa	"	"	(?)	Twice
Tænia echinococcus (Echinococcus polymorphus)	Larva	Connective tissue	Normal	Frequent
Tænia hominis	Adult	Intestine	" (?)	Once
Nematoda (round-worms)—				
Leptodera pellio	Adult	Vagina	Accidental	Once
Leptodera niellyi	Larva	Skin	Accidental(?)	"
Anguillula aceti	Adult	Bladder	Accidental	Rare
Strongyloides stercoralis	"	Intestine	Normal	Abundant
Gnathostoma siamense	"	Skin	Occasional	Once
Filaria medinensis	"	"	Normal	Abundant
Filaria loa	"	Eye	"	Frequent
Filaria volvulus	"	Lymph-vessels	(?)	Rare
Filaria conjunctivæ	"	Conjunctiva	Occasional	"
Filaria lentis	Young	Eye	(?)	Uncertain
Filaria restiformis	Adult	Bladder(?)	(?)	Once
Filaria hominis oris	(?)	(?)	(?)	"
Filaria labialis	(?)	Lip	(?)	"
Filaria lymphatica	Adult	Lymph-vessels	Occasional(?)	Twice
Filaria immitis	(?)	(?)	(?)	Uncertain
Filaria bancrofti	Adult	Lymph-vessels	Normal	Abundant
	Larva	Blood	"	Frequent
Filaria magalhæsi	Adult	Heart	Normal(?)	Rare
	Larva	Blood		
Filaria perstans	Adult	Connective tissue	" (?)	Once
	Larva	Blood		
Filaria diurna	"	"	Normal	Frequent
Filaria demarquayi	"	"	Normal(?)	Rare
Filaria romanorum orientalis	Adult	"	(?)	Once
Filaria ozzardi	Adult(?)	Connective tissue		
	Larva	Blood	Normal(?)	Rare
Filaria kilimaræ	Adult	Body cavity	(?)	Once
Trichuris trichiura	"	Colon	Normal	Abundant
Trichinella spiralis	"	Intestine	"	"
	Larva	Muscle,	"	"
Strongylus apri	Adult	Lung	Occasional	Rare
Strongylus subtilis	"	Stomach	Normal(?)	Twice
Dioctophyme renale	"	Kidney	Occasional	Rare
Uncinaria duodenalis	"	Intestine	Normal	Abundant
	Larva	Connective tissue	"	"
Uncinaria americana	Adult	Intestine	"	"
Physaloptera caucasica	"	"	(?)	Once
Ascaris lumbricoides	"	"	Normal	Abundant
Ascaris canis	"	"	Occasional	Rare
Ascaris maritima	" (?)	(?)	(?)	Once
Oxyuris vermicularis	"	Intestine	Normal	Abundant
Gigantorhynchus gigas	"	"	Occasional	Rare
Gigantorhynchus moniliformis	"	"	"	"
Echinorhynchus hominis	"	"	(?)	Once

? Record open to question.

of intestinal parasites in the United States are far more general than has heretofore been believed. The marked prevalence of different forms of intestinal parasites in those exposed to infection in the tropics is shown by the following report:

In Bulletin No. 13 of the Hygienic Laboratory of the Public Health and Marine-Hospital Service there was reported a statistical study of the intestinal parasites of 500 white male patients at the United States Government's Hospital for the Insane. A summary of the results obtained in this study shows:

1. That 13.2 per cent. of the patients examined were infected with intestinal parasites. The parasites found were hook-worms (Uncinaria Americana or Anchylostoma duodenale), whip-worms (Trichuris trichiura), seat-worms (Oxyuris vermicularis), Cochin-China worms (Strongyloides stercoralis), eel-worms (Ascaris lumbricoides). No evidence of infection with tape-worms, flukes, or coccidia was found.

2. The results obtained differ from those of most foreign investigators principally in the lower rate of infection, in the absence of tape-worms, and in the presence of hook-worms and of the Cochin-China worms.

3. The results show that the percentage of infection tends to vary inversely with the age and with the duration of institutional life of the patients.

4. They also indicate that army life is conducive to parasitic infection of the intestine, and, moreover, that a high percentage of the United States soldiers returning from service in the Philippine Islands have intestinal parasites.

5. The presence of a moderate number of worms in the intestine has no relation to the presence of undigested starch and meat in the dejecta or to the litmus reaction of the feces.

Frequency of Infection.—Of the 500 patients examined, 66 patients, or 13.2 per cent., showed parasitic infection of the intestines; 10 patients had a double infection, and in one case three different parasites were

present, making a total of 78 infections. These were distributed among five parasites as follows:

Uncinaria Americana, or Anchylostoma duodenale (hook-worms), 15 cases, or 3 per cent. of the cases examined.

Trichuris trichiura (whip-worms), 54 cases, or 10.8 per cent.

Oxyuris vermicularis (seat-worms), 4 cases, or 0.8 per cent.

Strongyloides stercoralis (Cochin-China worms), 3 cases, or 0.6 per cent.

Ascaris lumbricoides (eel-worms), 2 cases, or 0.4 per cent.

The Hook-worm Disease (*Uncinariasis*).—Stiles[1] states that—"This is a newly recognized factor in anemias in America. In traveling from Virginia to Florida, as we go south anemia increases. The cases may be divided into two general classes, one due to malarial infection and the other to the Uncinaria Americana. The former is especially prevalent where the soils are impervious, and the latter occurs in the sandy areas. At Waycross, in southeastern Georgia, there are about twenty cases of hook-worm disease to one case of malaria.

"The hook-worm disease of Europe is due to the Uncinaria duodenalis, while the American disease is caused by another species of the same parasite, known as the Uncinaria Americana. The parasites live in the small intestine and suck the blood. One factor in the production of the disease is the loss of blood taken by the parasite. In addition, minute hemorrhages occur from the wounds made by the worms. These wounds may ulcerate. The intestinal walls are thickened, and their digestive surface is decreased. The parasites apparently produce a poisonous substance. All these factors are involved in the symptoms of the disorder."

Infection with hook-worm occurs in all the Southern states. In many localities the infection is so severe as

[1] *Brooklyn Medical Journal*, 1903, vol. xvii, p. 51.

to lead to marked retardation in the growth of those children that are infected. The disease is disseminated through the lack of proper disposal of the feces of infected individuals. The ova are deposited on the soil, and when suitable conditions as to temperature and moisture exist, these develop into the larval stage. The larvæ penetrate through the skin and finally reach the intestinal canal. The disease is far more prevalent among those that go bare-footed than in those wearing shoes. The introduction of proper methods of disposal of human feces is by far the most important sanitary measure against this disease.

Trichinosis.—The Trichinella spiralis is ingested through the use of raw meat, more particularly raw pork, though among the flesh-yielding domestic animals, calves and sheep may also be infected. Rats, cats, and hogs serve as intermediate hosts of the parasite.

The thorough cooking of all meat will be a positive safeguard against infection from this parasite, as it is destroyed when heated above 65° C. for several minutes. Complete drying also destroys the parasite, and pickling the meat serves to kill the parasite in a few months.

Prevention of Infection with Animal Parasites.—In a paper presented to the International Congress of Hygiene (1891, vol. 1), Dr. Prospero Sonsino gives succinct directions for preventing this form of infection:

"1. Pure spring-water, or else boiled or filtered water, alone are to be drunk. Drinking-water is to be preserved in good and well-covered vessels. River- or lake-water not to be imbibed while bathing. This rule regards prevention especially from Bilharzia hæmatobia, Filaria sanguinis hominis, Ranunculus medinensis, Rhabdonema intestinale, and probably from Filaria loa and many others. The relatively large dimensions of the eggs and larval stage of entozoa hinder their passage with drinking-water through a good filter; therefore proper filtration of drinking-water suffices.

"2. Meat, fresh-water fish, and vegetables are to be well

cooked and kept from insects (flies). For children and invalids, raw meat can be used, provided that it is well pounded and passed through a suitable sieve. This rule regards prevention especially from Trichinella spiralis, Tænia solium, T. saginata (mediocanellata), Bothriocephalus latus, Ascaris lumbricoides, A. mystax, Distoma lanceolatum, Fasciola hepatica, and others. The modern use of raw beef for children and invalids has been the cause of an extraordinary spread of Tænia saginata.

"Depraved tastes for substances not possessed of alimentary qualities (pica and geophagia) are not to be yielded to. This rule regards the prevention from Tænia nana, leptocephalia, canina, and probably from Distoma heterophyes, Echinorhynchus hominis, Ascaris lumbricoides, A. mystax. Many of these entozoa have, or are suspected to have, insects as intermediary hosts, which may be conveyed to the stomach of man through the habit of those affected with pica and geophagia of eating dirty things.

"4. Special forms of food in use by the natives of countries possessing special entozoa are to be avoided, or only taken after thorough cooking. This rule is calculated to prevent Bothriocephalus cordatus, B. Mansoni, Distoma crassum, D. heterophyes, D. sinense, and D. Ringeri.

"5. Hands and nails are to be kept thoroughly clean, particularly when about to eat. Domestic animals are to be handled with caution—dogs especially. Caution in handling entozoa; their speedy and complete destruction by fire whenever it is not necessary to preserve them for medical purposes. This rule is of great importance, especially for preserving man from Anchylostoma duodenale, echinococcus, Pentastoma denticulatum, Tænia canina, T. solium, and Oxyuris vermicularis.

"6. The body is to be kept free from epizoa (mosquitoes, bugs, fleas, etc.). This rule is of great importance in guarding against some of the above-mentioned worms,

so as to interfere with the life-cycle of those parasites, as well as with that of several of the filariæ."

It is safe to assume that protection against epizoa will be of value in preventing infection from a number of other diseases the specific causes of which are as yet undetermined. Our knowledge with regard to the dissemination of disease by means of insects has been carefully summarized by Nuttall.[1]

Vegetable Parasites.—The vegetable parasites are less formidable in their action than the animal parasites. The diseases due to the vegetable parasites are usually slow in development and less destructive in their action.

The *Trichophyton fungus* is a common parasite among the poorer classes. The diseases produced by it are known as tinea circinata, tonsurans, and sycosis, according to the location of the disease. Cleanliness and simple antiseptic treatment serve to eradicate the disease.

The *Microsporon furfur* produces the disease known as tinea versicolor, and is but slightly contagious. The Achorion Schönleinii produces the disease known as tinea favosa, which is distinctly contagious in character and difficult to eradicate. The Microsporon minutissimum produces the disease known as erythrasma, which is similar in many respects to tinea versicolor.

Actinomycosis is a disease due to an organism which is regarded as being higher in the scale of the vegetable kingdom than the bacteria, and may be briefly considered here. A considerable group of organisms has been discovered which have some of the characters of the ray fungus, among which are the Bacillus tuberculosis and the related "acid-fast" organisms found in butter, hay, and grass. This whole group of organisms, including the Bacillus tuberculosis is sometimes classed together under the name actinomycetes.

The Actinomycosis bovis, or ray fungus, affects man as well as animals. It is believed to gain entrance to the body through carious teeth. It produces deep subcutaneous swellings or tumors, which finally break down

[1] *Hygienische Rundschau*, Jahr. 9, 1899.

and suppurate, discharging a thin, bloody sero-pus containing characteristic yellow granules.

The disease often yields to the administration of large doses of potassium iodid.

Actinomyces maduræ is a vegetable parasite which is the cause of an endemic disease known as Madura foot, and which is characterized by disintegration of the tissues, chiefly of the foot and hand. The disease occurs most frequently in India, though Wright encountered a case in Boston. The disease pursues a chronic course, and the only successful treatment is by means of the knife or curet.

Oïdiomycosis.—Ricketts[1] has collected a number of cases of disease of the skin which were traced to organisms belonging to the genus Oïdium. The variations among the organisms represented three morphologic types : (1) Blastomycetoid or yeast-like ; (2) oïdium-like ; (3) hyphomycetoid.

The *Oïdium albicans* is the organism which produces thrush, a disease of the mucous membranes in enfeebled infants.

The Oïdium lactis is found in sour milk, on bread and decayed fruit, and, so far as known, is non-pathogenic. It is frequently encountered in the mouth.

Sporotrichosis.—According to Ruediger[2] 57 cases of sporotrichosis have been reported in the United States, 50 cases in France, and 1 or 2 in Germany. Of the cases reported in the United States five-sixths of the total of 57 cases have been observed in the valley of the Missouri River, the remaining 10 cases being widely scattered from the Atlantic to the Pacific coast. Ruediger believes that the parasite lives as a saprophyte on grains, grasses, or other vegetation, as the disease is seen most frequently among farm laborers; but there is no direct evidence that the infection in man is contracted from horses.

[1] *Jour. of Med. Research*, 1901, vol. vi.
[2] *Jour. of Infectious Diseases*, vol. xi, p. 193.

Hospital for Infectious Diseases.—Where satisfactory isolation is impracticable the city should provide special hospitals for infectious diseases. This arrangement lessens the hardships of isolation, and may be instrumental, under proper regulations, in favoring the system of notification.

The special need of pay hospitals for infectious diseases has long been felt. Even where the patient could be satisfactorily isolated and treated in the home, there is a feeling that the pecuniary loss and inconvenience of house quarantine are much greater than the expense of hospital treatment. Consequently those that are able and willing to pay for hospital treatment cannot be accommodated anywhere except at the municipal hospital, and there is frequently objection to going to a public institution. It is safe to state that the time is not far distant when every large city will have pay hospitals for the reception of cases of infectious diseases. Such hospital treatment would overcome the obnoxious house quarantine practised to-day, at least as far as those are concerned whose time is most valuable from their business associations.

CHAPTER XVIII.

DISINFECTION.

Aside from the prophylactic measures already spoken of, there are other measures in common use to limit the spreading of the infectious diseases. These measures are employed to destroy the specific bacteria and other infective agents outside the body. These measures are commonly included under the broad term disinfection. To disinfect is to render non-infective, and a disinfectant is, therefore, any agent that is capable of destroying infective materials or of rendering them inert. Chemical substances which in certain definite proportions kill bacteria in fluids are disinfectants. When present in the large amounts they act as germicides—that is, they kill the bacteria; while in the smaller amounts they are simply deterrants, because they render the bacteria incapable of multiplication. The term "disinfectant" is also sometimes applied to substances which destroy bad odors. This is, however, an improper use of the term disinfectant. These substances which destroy bad odors are deodorants, and may or may not be disinfectants. Substances which retard or prevent the growth of bacteria are usually spoken of as antiseptics, because they prevent the growth of the septic bacteria as well as others. These antiseptic substances, in larger amounts, generally are germicides.

A reliable disinfecting agent is, therefore, one that is germicidal in its action. A good disinfectant should, however, be as free as possible from poisonous action upon those who use it, and, at the same time, it should not be destructive to the articles to be disinfected. The latter quality is a most important one from the fact

that a number of very useful disinfecting agents have an injurious or even destructive action upon the articles to be disinfected. For this reason dry heat is not applicable to the disinfection of fabrics, because the degree of heat required to disinfect thoroughly would be sufficient to char them. Articles of clothing containing blood or other stains should not be disinfected by means of hot water or steam, because these agents fix the stains so that they remain permanent. Many of the other disinfecting agents have a corrosive action upon metals, and are, therefore, not adapted for the disinfection of metallic articles. Consequently it is necessary to select that disinfecting agent which is least likely to prove objectionable. Fortunately we have a rather wide range of substances and agencies to select from according to the nature of the articles to be disinfected.

The disinfecting agent should be cheap, in order to lessen the expense as much as possible. Here again it is possible to select, for certain purposes, agents that are comparatively cheap and yet quite efficient. Under other circumstances it is not possible to avail ourselves of the cheapest agents, because they are not suitable for other reasons. For instance, milk of lime is a most excellent disinfectant for rough work, but it would not be applicable under all conditions.

All our present knowledge of the value and efficiency of the different disinfecting agents is based upon laboratory experiments, and it is only since the evolution of modern bacteriology and the perfection of bacteriologic methods that it was possible to give intelligent direction to our efforts toward the limitation and eradication of disease by such means.

The strength of all disinfectants is tested and compared with the value of a 5 per cent. solution of phenol, using Bacterium typhosum as the test object. The relative strength of the unknown disinfectant is expressed as the phenol coefficient. All commercial disinfectants are marketed with a statement of their phenol coefficient.

While a room is occupied as a sick room constant at-

tention must be given to the floor, walls, furniture, especially the door-knob, to keep everything clean and safe. Ordinary cleansing with soap and water will help to keep the objects in the room free from gross infection if all the secretions of the patient are promptly disinfected. In addition to soap and water a mild disinfectant solution may be used in cleaning the furniture, walls, and floor.

Some sanitarians have regarded the terminal disinfection of infected houses as valueless, and claim that by proper attention to the handling of the patient and his excreta terminal disinfection could be omitted. While others grant that it is possible through intelligent oversight to prevent the dissemination of the infecting bacteria, it is, however, certain that the necessary precautions are not exercised, and hence it is unsafe to omit terminal disinfection.

Disinfectants in Common Use.—The disinfectants in common use are of two classes, heat and chemical substances. Heat may be employed as a disinfectant in several different ways—as dry heat, 150° to 175° C., for one to two hours; or as moist heat, as steam or boiling water. The principal chemical disinfectants are formaldehyd gas and solution, mercuric chlorid solution, carbolic acid solution, trikresol, chlorid of lime and caustic lime, sulphur dioxid, zinc chlorid, and copper sulphate. Fire is also a most efficient disinfectant, but is applicable only for substances that are not combustible, or for combustible substances that are of little or no value. Sunlight is also an efficient disinfectant. This agent is constantly acting and, no doubt, removes most of the detrimental agents on surfaces exposed to the sun. Most bacteria grow best in the dark. Many species fail to grow at all in diffuse daylight, while direct sunlight is injurious to all species.

The Action of Sunlight Upon Bacteria, With Special Reference to Bacillus Tuberculosis.—J. Weinzirl[1] made a study of the various methods which have

[1] *Jour. Infect. Diseases*, May, 1907, Sup. 3, pp. 128–153, pls. 2.

been used in determining the effect of sunlight upon bacteria. Objections are found to most of these methods in that they do not constitute true exposures, the bacteria being covered with glass or other material which absorbs and deflects some of the sun's rays. When bacteria were directly exposed to the rays of the sun without any covering over them, the author found that the germicidal action of sunlight was much more effective than it had previously been considered.

The organisms upon which observations were made were the bacilli of tuberculosis, typhoid fever, cholera, diphtheria, etc., but particular attention was given to the tubercle bacillus. It was found that this organism, as well as other pathogenic non-spore-bearing bacteria, is destroyed in from two to ten minutes by direct exposure to sunlight. According to the author, the hygienic importance of sunlight has been considerably underestimated and nonspore-bearing bacteria, when freely exposed, are killed in from one-fifth to one-twentieth of the time previously considered necessary.

Disinfection on Large Scale.—Disinfection on a large scale, for infected clothing and bedding, is usually accomplished by means of steam under pressure. A special form of apparatus is required for this purpose (see Fig. 60). A special building should be constructed for a municipal disinfecting plant. The disinfecting chamber should be so arranged that the infected clothing is brought into one room, where it is introduced into the disinfecting chamber. After it has been disinfected, it is taken out of the chamber from the other side of a partition wall and stored in a room that has no connection with the first room except through the disinfecting chamber. The doors of the disinfecting chamber should be so arranged that only one can be opened at a time, so as to prevent infectious materials from being carried over into the room containing the disinfected clothing. The attendants handling the infected clothing should not come in contact with those who handle the disinfected clothing. The disinfected clothing should never be re-

turned in the same conveyance used for the collection of infected clothing.

The disinfecting power of steam is dependent upon the extent of the pressure to which it is subjected, the greater the pressure the higher its disinfecting power, because the temperature of the steam increases with the increased pressure. The steam given off

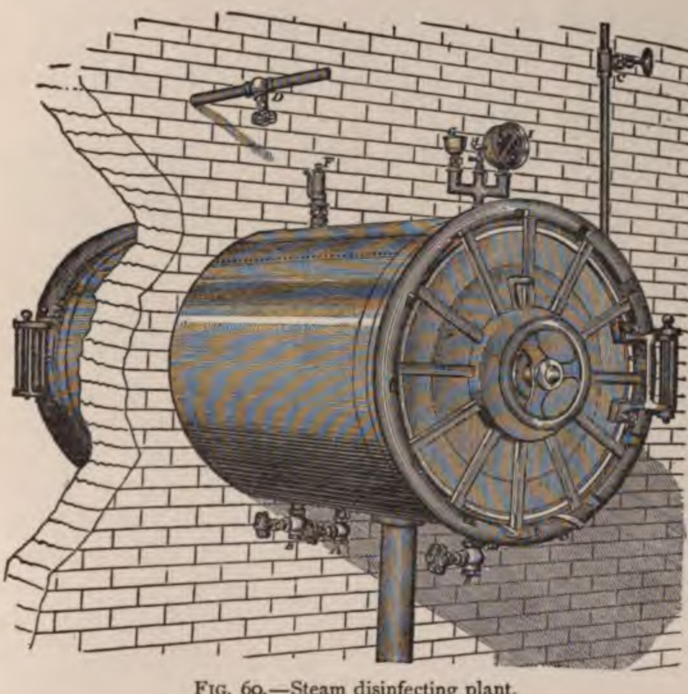


FIG. 60.—Steam disinfecting plant.

from boiling water in an open vessel has the same temperature as that of the water—100° C. At one additional atmosphere pressure we obtain a temperature of 121.5° C.; at two atmospheres, 135° C.; at three atmospheres, 145° C.; at four atmospheres, 153.3° C.; and at five atmospheres, 160° C. A pressure of one atmosphere is equal to 1 kilogram per square centimeter of surface.

Spores are not destroyed when heated to the temperature of boiling water, but at a pressure of two to three additional atmospheres disinfection by steam kills spores almost immediately. All pathogenic bacteria in the vegetative stage are killed when heated to from 65° to 75° C., so that the temperature of boiling water is sufficient to kill a large number of the different species of pathogenic bacteria—the non-spore-bearing forms. When infected clothing and bedding are to be disinfected by steam, it is necessary to use steam under pressure to cause the heat to penetrate into the interior of the bundles to be disinfected.

Formaldehyd.—Of the different chemical disinfectants, formaldehyd is now considered the most efficient, and is in general use for the purpose of room disinfection. The disinfectant action of formaldehyd was discovered in 1886 by O. Loew. The formaldehyd gas, as generally employed for purposes of disinfection, has no great penetrating powers, and it cannot, therefore, be relied upon for the disinfection of bundles of clothing and bedding. For the disinfection of such articles the gas must be applied under pressure by means of a vacuum chamber. This disinfectant is most commonly used for the disinfection of rooms in which there have been cases of infectious diseases. It is entirely harmless for all classes of household goods. Upon the removal of the patient the room is closed as tightly as possible, and all cracks are closed with gummed paper; all the bedding and clothing are spread out, the drawers, doors of cupboards, and closets are opened, and the gas is introduced through the keyhole of the door. The gas is generated in a special apparatus outside the room either from an aqueous solution of the gas by the application of heat, by the oxidation of wood alcohol, or by the volatilization of paraform.

Generation of Formaldehyd Gas.—An excellent form of formaldehyd gas regenerator is that manufactured by Lentz & Sons, of Philadelphia (Fig. 61), which consists of a stout copper retort of about 2½ liters (4 pints) capacity, with funnel filling tube and level

indicator, a stopper of special construction, and inclined brass outlet tube of large bore, connected by means of a flexible tube with another and smaller brass tube, which is inserted through the keyhole of the room to be disinfected.

The solution in the retort is heated by a special form of "Primus" lamp, D, which burns kerosene and develops a temperature of 1150° C. (2100° F.). The solu-

FIG. 61.—Formaldehyd gas regenerator.

FIG. 62.—Formaldehyd gas regenerator.

tion is introduced into the bottom of the retort through the small funnel at the top, and the stopcock A on the connection is allowed to remain open, so that exhaustion of the solution is at once detected by the escape of gas. The cap of the retort is held in position by a strong iron yoke, provided with a clamping screw, B. When the supply of solution in the retort is exhausted the flame is

at once extinguished by turning the thumb-screw F to the left. If it is desired to continue the disinfection, a filled retort can be substituted for the exhausted one by turning the screw C, which holds the retort in place. The heat of the flame is perfectly under the control of the operator. It can be increased by use of the pump G, or decreased by opening the valve F.

The efficiency of this apparatus is attested by the fact that the United States War Department has over one hundred of them in use, besides large numbers in use by boards of health in many of the larger cities, by hospitals, schools, and physicians.

Figure 62 represents the Trenner-Lee formaldehyd regenerator, for which certain important advantages are claimed. It is so constructed as to permit its use either within the room to be disinfected or outside the room. The introduction of copper plates in the interior of the retort serves to prevent the frothing of the boiling fluid, and hence prevents the projection of fluid from the apparatus. The use of a large alcohol burner makes it possible to generate the gas very quickly, rapidly, and uniformly, and the amount of alcohol in the burner can be so regulated as to become exhausted and extinguish the flame when all the solution has been utilized. This is an important advantage when the apparatus is to be placed in the room to be disinfected.

The formaldehyd gas acts most efficiently when moist and at a high temperature. To meet these conditions the gas is either mixed with steam or it is generated from a mixture of formaldehyd solution and glycerin. The glycerin prevents the gas from polymerizing as readily as when in the dry state. The moisture may be supplied also by spraying all the surfaces of the room, as well as all articles contained in it, with a solution of formaldehyd before beginning the disinfection, or by suspending sheets, saturated with formaldehyd, in the room. It is entirely harmless in its action upon fabrics, and is not highly poisonous, though it has an irritant

action upon the mucous membrane when respired.[1] The formic aldehyd solution contains about 40 per cent. of the gas, and is relatively cheap. It can be purchased everywhere in this form, and is also sold, at a much higher price, under the trade name of "formalin." From 500 to 600 cubic centimeters of the glycerin-formaldehyd mixture (1 : 50) are usually employed to disinfect a space of from 25 to 30 cubic meters. A liter of wood alcohol will yield 748 grams = 361 liters of aldehyd. This amount of gas in a room of 25 to 30 cubic meters would give 1.25 to 1.5 per cent. of aldehyd in the air of the room. Stüver concludes that a closed room must contain 2.5 grams of formaldehyd per cubic meter of space. 1.6 grams per cubic meter kills all organisms not in the spore stage. The room should remain closed for six hours after the gas has been generated.

Liquid Formaldehyd-spraying.—The Board of Health of Philadelphia has for some years abandoned formaldehyd generators, and has relied solely upon the spraying of infected rooms with formaldehyd by means of a large spraying apparatus. There is no doubt that the disinfection of houses as practised to-day is not always efficacious. Disinfection by burning sulphur in a room is almost valueless for the bacterial infections, since it is impossible to generate sufficient sulphur dioxid in this manner to kill the pathogenic organisms. In like manner the generation of formaldehyd gas by the different methods in use is rarely efficacious, since in practical experiments, under the most favorable conditions that can be improvised, only about 80 per cent. of the test organisms are killed. The use of formaldehyd in solution by means of a large spraying apparatus gives the most satisfactory results, as in this way it is possible to destroy 100 per cent. of test objects. With such an efficient method of disinfection in use we may hope to

[1] Disinfection with formaldehyd has been rendered quite safe, with regard to danger from fire, since the modern apparatuses permit the evolution of the gas outside the room to be disinfected, the gas being conducted into the room through the key-hole.

see a more prompt subsidence of outbreaks of the transmissible diseases than has ever been the case. Moreover, this method of disinfection is unattended with the dangers of fire that always attend the older methods. Three pints of equal parts of formaldehyd (40 per cent. solution) and water is sufficient to disinfect a room having 1000 cubic feet of space. This solution is sprayed over the bedclothes, furniture, walls, floors, etc., and is allowed to act for twenty-four hours, after which the room may be thoroughly aired.

Sulphur Dioxid.—Sulphur dioxid was formerly employed to a large extent for the purposes for which formaldehyd is now employed. The gas is generated by burning ordinary sulphur in the room to be disinfected. All the crevices and cracks in the room should be closed as carefully as possible, so as to retain the gas in as large volume as possible within the room. It should form from 4 to 10 per cent. of the volume of the air of the room, and should be allowed to act from twelve to twenty-four hours. To generate this amount of the gas, it is necessary to burn about 1½ kilograms of sulphur for each 25–30 cubic meters of space. This gas also acts most efficiently in a moist state—in fact, it is of small penetrating power in the dry state. The moisture may be generated by spraying the articles in the room or by introducing steam during the time the gas is being generated.

The use of sulphur dioxid for purposes of disinfection is, at present, largely confined to the disinfection of ships.[1] The preference of sulphur dioxid over formaldehyd in the disinfection of ships is due to its efficiency in the destruction of rats and other vermin. In this respect sulphur dioxid is far more efficient than formaldehyd. In vessels infected with plague it is especially desirable to destroy all rats on board ship because of their evident capability of serving as carriers of the infection.

Hydrocyanic Acid.—Recently the use of hydrocyanic acid has been advocated for the disinfection of rooms.

[1] See Sect. 162 of the Quarantine Laws of the United States, p. 482.

Aside from its value in the destruction of pathogenic bacteria, this gas possesses the additional value of being particularly efficacious in the destruction of vermin. Contrary to the generally accepted opinion, this gas is claimed to be far less dangerous to those employing it than was formerly supposed to be the case.

Corrosive Sublimate.—For a long time corrosive sublimate had been regarded as the most reliable and efficient disinfecting substance, on account of its high germicidal powers, but it is less highly esteemed at the present time, because it has been found to have certain very important limitations. It is a most highly poisonous substance, and is therefore not safe for general use. It is also objectionable from the fact that it is precipitated by albuminous substances, and consequently it should not be employed in the presence of such substances. The addition of acids prevents the destruction, to some extent, of the corrosive sublimate through combination with albuminous substances. Tartaric or sulphuric acid is best adapted for this purpose. Because of its poisonous effects, it is customary to add one of the anilin dyes to give it a distinctive color and thus limit the danger of accidental poisoning. It is capable of fixing permanently any stains on clothing, and is, in consequence, not adapted for use with such materials. It kills all bacteria and their spores in a few minutes in 1 : 1000 solution, and in a few hours in 1 : 5000 solution. The mercury unites with the protoplasm of the organisms and forms albuminate of mercury, and thus kills them.

Carbolic Acid.—This is a very active germicide, and is therefore an efficient disinfectant. It is sparingly soluble in water, the extreme being about 5 per cent. in saturated solution. A solution of this strength kills bacteria in the vegetative stage in less than a minute. Like corrosive sublimate, carbolic acid is also rendered less effective by the presence of albuminous substances in the material to be disinfected. The addition of sulphuric acid increases

its action, and for the roughest work a mixture of equal parts of crude carbolic acid and commercial sulphuric acid is most serviceable. This mixture is employed in 2 to 3 per cent. solution. Another mode of employment is in the form of carbol soap. This mixture is of great value in the disinfection of soiled clothing and bedding, inasmuch as it does not fix the stains, and yet disinfects them efficiently.

Trikresol.—The cresols are most efficient disinfectants, and are contained in considerable quantities in crude carbolic acid. Trikresol is a mixture of the three cresols, para-, meta-, and ortho-cresol, in the following proportions: Para-cresol, 25 per cent.; meta-cresol, 40 per cent.; ortho-cresol, 35 per cent. This mixture is soluble in water in the proportion of 2 to 5 per cent. It is poisonous, and its action is also increased by the addition of sulphuric acid.

Creolin.—This substance has a high disinfectant value. It is insoluble in water, but is employed as an emulsion in water in the proportion of 2 to 5 per cent. It is used for rougher work, as around kennels, stables, and cellars.

Nitrate of Silver.—The use of this substance is limited by its cost, its poisonous qualities, and the facility with which it is precipitated by albuminous substances. It appears, however, to possess special value as a disinfectant of the throat in convalescent cases of diphtheria. The application of a 20 per cent. solution of nitrate of silver to the throat, as recommended by Dr. Hand, serves to render it free from diphtheria bacilli in about seven days, while the average length of time that they persist in throats treated by other methods is about twenty-eight days.

Preparations of Lime.—**Chlorinated Lime.**—This is one of the most serviceable disinfectants known at the present time on account of its cheapness and because it is not so highly poisonous as many of the other disinfectants in use. It should contain at least 25 per cent. of available chlorin as hypochlorite. In 0.5 to 1 per cent. watery solution it kills typhoid and cholera organisms in ten min-

utes. It is especially adapted for the disinfection of typhoid stools and for use in the disinfection of school-rooms and school furniture. The odor of chlorinated lime may be readily removed by exposing cloths saturated with a solution of washing soda in the room where lime has been used.

Milk of Lime, or whitewash, is also a serviceable disinfectant, and is usually employed in the disinfection of cesspools and privy-vaults. It is a most efficient deodorant, and in this respect it serves a double purpose when applied to walls of cellars, etc.

Washing Soda.—This is a serviceable disinfectant, and no doubt serves a good purpose when applied to floors in the ordinary cleansing operations. In 2 per cent. solution it is an efficient disinfectant for instruments when boiled in it for ten minutes.

Sulphate of Iron.—For rougher work, as privy-vaults, cesspools, etc., this substance is most frequently employed. It is not a strong disinfectant, but it is serviceable as a deodorant. It should be used in the proportion of 1 kilogram (dissolved in 10 liters of water) to a cubic meter of the contents of the vault.

Physical Agents.—The principal physical agents employed for purposes of disinfection are dry and moist heat, fire, and sunlight.

Dry Heat.—This agent is not employed in ordinary disinfection. Its use is confined to the laboratory, where it is employed in the disinfection of glassware, etc.

Moist Heat.—The use of moist heat is almost universal, and has many advantages over chemical disinfectants. It is entirely safe and very efficient, besides being cheap, so that it has all the requisites. It may be employed in the form of boiling water or in the form of steam. Boiling water added in double quantity to typhoid or cholera stools disinfects them in an hour. It kills the diphtheria bacillus in five minutes, and the tubercle bacillus in ten minutes, and consequently it is most serviceable for the disinfection of napkins soiled with the discharges of diphtheria or tubercular patients.

Steam is now used largely in the disinfect clothing and bedding, such as mattresses and p which cannot be disinfected by means of hot wat special apparatus is required for the larger pieces boards of health are obliged to deal with.[1] In th room an ordinary potato-steamer or the ordinary sterilizing apparatus may be employed.

Fire, of course, is the best of all disinfectants, b it is positive in its action. It can, however, be em only in the destruction of infected articles that little or no further use. It is frequently best to re the use of this efficient disinfecting agent, even infected articles are of slight value, because we ar certain no danger can result therefrom.

Sunlight.—The direct action of the sun's ray non-spore-bearing organisms in half an hour. I however, but little penetrating power, and conseq it is of limited applicability. The combined inf of sunlight and drying as a purifying agent shou be altogether ignored, but should not be relied exclusively.

Disinfection of Infective Materials.—The ical disinfectants are used principally by direct a tion to infected materials. Mercuric chlorid is u solutions of 1 : 500 to 1 : 4000 strength. Carbolic used in 2 to 5 per cent. solutions. Chlorid of li employed in 0.5 to 1 per cent. solution, prepared f preparation having from 25 to 30 per cent. of av chlorin.

Disinfection of Excreta.—For the disinfecti excreta solutions of carbolic acid and chlorid of are usually employed. The excreta should be well

[1] In these large steam disinfecting apparatuses the air can be exhau the steam retained under pressure. With increase in pressure there crease in temperature, and consequently an increase in the effectivene operation. At 760 mm. barometric pressure water is turned into 100° C. (212° F.). At a pressure of one additional atmosphere we temperature of 121.5° C. (250° F.). At a pressure of two additiona pheres we obtain a temperature of 135° C. (275° F.).

with equal quantities of the disinfectant solution, and allowed to stand for several hours before they are finally disposed of. Milk of lime, or caustic lime, may also be used for this purpose. Mercuric chlorid solution is not adapted for the disinfection of excreta, because the albuminous material present combines with the mercury to form insoluble albuminate of mercury, which is inert. Mercuric chlorid is not adapted for the disinfection of clothing and bedding, because it fixes any stains that may be present, and thus prevents their subsequent removal.

In order to obviate the destruction of the disinfectant properties of mercuric chlorid through the agency of albuminoid materials, acids may be added to the solution. In France the following mixture is employed:

Mercuric chlorid	2 grams.
Tartaric acid	24 "
Water	1000 "

A few drops of a 5 per cent. solution of carminate of indigo are added to give the solution a distinctive color.

In England the following mixture is employed:

Mercuric chlorid	1 ounce.
Hydrochloric acid	10 ounces.
Water	1 gallon.

This solution is colored with anilin blue.

Disinfection of the Sick-room.—The disinfection of the sick-room during the time it is occupied by the patient is essential to prevent the spread of infectious diseases. The prophylactic measures necessary are dependent upon the nature of the disease, though, in a general way, they may be summarized under three divisions: First, those applicable to the exanthemata; second, those applicable to diseases of the respiratory apparatus; and third, those applicable to diseases of the gastro-intestinal tract. The principal diseases falling within the first group are small-pox, measles, and scarlet fever; those of the second group are diphtheria, pneumonia,

and tuberculosis; and those of the third group are cholera, dysentery, and typhoid fever.

In the Exanthemata.—In the first group of diseases the infectious material, whatever its nature, seems to be thrown off principally from the skin. It is most essential, therefore, to prevent the emanations from the skin gaining access to the air of the room. This is best accomplished by daily anointing the patient's body with some bland oil. The bed-clothing is to be removed with as little agitation as possible, and at once placed in a tub of water or a weak antiseptic solution before it is removed from the room. The floor, walls, furniture, and all horizontal surfaces in the room should be wiped daily with a damp cloth. The cloth may be dampened with a 2 per cent. solution of carbolic acid to increase the efficiency of the cleansing operation. There should be abundant ventilation of the room, and the most scrupulous cleanliness. As soon as any article of clothing or bedding is soiled, it should be removed in the manner described. The sick-room must be rigidly isolated from the remainder of the house, and the family must be excluded from it.

In the Respiratory Diseases.—In the diseases of the second group the infectious material is contained in the secretions of the nose and throat and in the expectorations. The most rigid care must, therefore, be exercised in the collection and removal of this material. Great care must be taken to prevent the patient from infecting his hands and person, and thus everything with which he comes in contact. The sputum should be collected in a special receptacle containing a disinfectant solution; this receptacle must be removed once or twice daily, emptied, and disinfected. The patient's hands must be disinfected frequently with a solution of chlorid of lime or of carbolic acid. The nurse also should disinfect her hands after each handling of the patient. The clothing and bedding must be removed as soon as soiled, in the manner described under the first group of infectious dis-

eases. The room must also be disinfected in the manner already described. The table utensils used in feeding the patient should be disinfected before they are mixed with those in use by the family. All food not eaten by the patient should be destroyed.

In the Intestinal Diseases.—In the third group of diseases the infectious material is contained in the urine and feces and in the vomit. All these excreta must be disinfected by means of equal quantities of chlorid of lime solution or 5 per cent. carbolic acid solution. Special care is necessary in the care of the patient's hands and person. Daily disinfection of the body of the patient is necessary. All soiled clothing and bedding must be removed and disinfected. The nurse's hands should be disinfected after handling the patient.

In the intestinal diseases special attention should be given to the purity of the water-supply. All the water used for drinking-purposes should be boiled whenever it is believed to be the source of the infection. This applies not only to the water used by the patient, as is sometimes directed, but to all the water used by the household or community using the water for domestic purposes.

When these prophylactic measures are carefully followed, the air of the room should be practically free from infective dust. This is the principal danger in all the infectious diseases, aside from direct contact with the patient, his clothing, or the excreta. There is no danger of contracting any of the infectious diseases from the breath of the patient. None of the specific pathogenic organisms are given off with the expired air in ordinary quiet respiration. Bacteria may be projected from the mucous surfaces of the mouth and nose in coughing, sneezing, or energetic talking, but never in quiet respiration.

In Other Infectious Diseases.—The prophylactic measures necessary in the other infectious diseases will be apparent to anyone who is familiar with their character and the excreta with which the infectious material leaves

the body. Common sense will teach any intelligent person to apply the prophylactic measures in the right direction if these factors are borne in mind.

Disinfection of Habitations.— After recovery or death from cholera, small-pox, relapsing, typhoid, typhus, and scarlet fevers, diphtheria, measles, cerebrospinal meningitis, and severe dysentery, the effects and rooms occupied by the patient during sickness should be promptly disinfected. All large municipalities have a specially trained force of men who carry out the details of disinfection of habitations before the placard is removed from the house.

The clothing and bedding which are to be disinfected by means of steam should be carefully wrapped in cloths saturated with 1 per cent. carbolic acid solution, placed in a wagon, and taken to the disinfecting station. After the bed has been stripped, all refuse matter, paper, and articles of little value are wrapped in cloths saturated with carbolic acid and burned in a stove or furnace.

The floor, doors, windows, furniture, and the walls for a distance of 1½ meters from the floor should be washed with 5 per cent. carbolic acid solution. The walls and ceiling of the room should subsequently be sprayed with 1 : 1000 bichlorid of mercury solution. If the walls are papered, it is advisable to remove carefully the paper before beginning the disinfection. The room is then closed as tightly as possible and disinfected by means of formaldehyd.

In the disinfection of habitations after diseases of the alimentary type the hopper of each water-closet should be disinfected by pouring into it 3 liters of chlorinated lime; and the householder or landlord should be instructed to use in the same manner 1 liter of chlorinated lime daily for several days afterward.

The vessels in which the excretions of the patient (stools, vomit, sputum) had been collected should be washed with 5 per cent. carbolic acid solution, and then

filled with the same solution and allowed to stand for twenty-four hours before they are emptied.

Disinfection of the Patient.—After convalescence has been established the question arises, How soon may the patient mingle with the remainder of the family without danger of carrying the infection? It is quite evident that this period of time will vary not only with different diseases but also in the same disease. This is manifest when we take pains to determine the length of time during which virulent diphtheria bacilli persist in the throat after all symptoms have subsided. This has extended over a period of three months or more in some cases, the average being about four weeks.

In the exanthemata it is customary to raise the quarantine when the physician reports the recovery of the patient, but the child is not allowed to attend school for thirty days afterward. As long as we do not know definitely the cause of the exanthemata, it is safest to fix some arbitrary time during which these patients must still be regarded as dangerous to the well.

In diphtheria it is possible to determine when the patient is free from the infectious agents by bacteriologic examination. As soon as the throat, nose, and the accessory cavities are free from diphtheria bacilli, the patient may safely mingle with the well. Unfortunately, in the exanthemata we are unable to apply any such practical test. The only test we possess is completion of desquamation.

In typhoid fever it has been found that the bacilli persist in the urine and feces for a considerable time, and here also it is possible to apply the cultural test to determine the time when the patient is no longer a menace to the community.

Wherever possible convalescents from diseases of the intestinal tract should be kept under observation until cultures of the intestinal discharges are found free of the causative organisms on three occasions at intervals of about five days.

When the patient has recovered from an infectious disease, he should be given a general bath with soap and water. In addition to this, he may be bathed with chlorinated soda solution, and in the exanthemata it may be advisable to anoint his body again unless all desquamation has ceased. After a general bath has been given, the patient may be allowed to mingle with the well.

In most localities the convalescent from certain diseases, especially small-pox, is washed with 1 : 2000 bichlorid of mercury solution, clothed with clean clothing, and then transferred to a disinfected room.

Disinfection of Public Conveyances.—The danger of disseminating disease through public conveyances has led to a great deal of discussion, and in many communities it has passed beyond the stage of discussion. Many local and State boards of health prohibit the promiscuous expectoration in public places which was once so common. The danger of disseminating infectious diseases by allowing sick persons to be conveyed in the ordinary public conveyances has led to the appointment of a committee on car sanitation by the American Public Health Association. This committee rendered and had adopted the following report:

"1. When a passenger is known to be contagiously ill, he should be isolated in a compartment appropriately equipped and ventilated in such a manner as to separate it from the rest of the car. Through trains should be provided with rooms for the sick as well as state-rooms, interchangeable in use.

"2. The interior of passenger cars should be plain, and finished with hard, smooth, and polished surfaces.

"3. All furnishings should be as non-absorbent as possible.

"4. Coaches should be furnished with effective means for continuously supplying not less than 1000 cubic feet of warm air an hour for each single seat, and for dis-

tributing and removing the air without troublesome draught.

"5. The temperature should be regulated.

"6. The cleaning of cars should be frequent and thorough.

"7. Floors and sanitary lavatory fixtures should be frequently treated with a disinfecting wash.

"8. All fabrics in cars should receive sterilizing treatment. All bed and lavatory linen should be thoroughly sterilized in the process of laundering.

"9. Sewage-tanks and earth-closets should be provided under the cars. The practice of disposing of excreta by scattering it over roadbeds is dangerous.

"10. Water and ice should be obtained from the purest available sources. The use of tongs in handling ice should be insisted upon.

"11. The water-tank should be frequently cleansed and periodically sterilized with boiling water or otherwise.

"12. The public should be educated to use individual cups. Paper . paraffined cups might be provided by a cent-in-the-slot device.

"13. The use of canned goods in buffet-car service makes careful inspection of such goods imperative. Fruits and all eatables before and after purchase should be stored with care, to avoid all unnecessary exposure to street and car dust.

"14. The filthy habit of spitting on car floors should be dealt with in a manner to cause its prompt discontinuance. It should be punished as one of the most flagrant of the thoughtless offences against the public right to health.

"15. Station premises should receive attention directed to general cleanliness of floors, furnishings, air, sanitaries, lavatories, platforms, and approaches, and should be plentifully supplied with approved disinfecting material."

The Disinfection of Libraries.—Formaldehyd gas may be conveniently applied for the disinfection o

books by the use of a Schering lamp. A perfectly tight box should be provided. It should be lined inside with a heavy calendered paper, and the joints tightly closed. The books should be opened out with all leaves exposed, and placed on shelves or racks within the box.

More convenient than a box would be a small closet with a lattice-work or shelves upon which to expose the books.

The problem of disinfecting a number of books at once is quite a difficult one. Library books are infected through handling. The infection is apt to adhere to the leaves of the book, and each individual leaf must be opened in such a way as to become penetrated by the formaldehyd gas. Large libraries are now generally equipped with disinfecting apparatus so as to be in a position to disinfect books that may have been in relation with any of the infectious diseases.

Barber-shops.—The danger of contracting disease in barber-shops is now receiving more general recognition. The selection of a barber is evidently a matter of some consideration, and should be influenced largely by the care which he exercises to prevent the dissemination of contagion. Health Commissioner Lederie recently issued the following ten rules for the governance of barbers in Greater New York:

1. Barbers must wash their hands thoroughly with soap and hot water before attending any person.

2. No alum or other astringent shall be used in stick form. If used at all to stop flow of blood, it must be applied in powder form.

3. The use of powder-puffs is prohibited.

4. No towel shall be used for more than one person without being washed.

5. The use of sponges is prohibited.

6. Mugs and shaving-brushes shall be thoroughly washed after use on each person.

7. Combs, razors, clippers, and scissors shall be thoroughly cleansed by dipping in boiling water or other germicide after separate use thereof.

8. No barber, unless he be a licensed physician, shall prescribe for any skin disease.

9. Floors must be swept or mopped every day and all furniture and woodwork kept free from dust.

10. Hot and cold water must be provided.

Similar rules have been adopted by the Board of Health of New Orleans and of other cities.

CHAPTER XIX.

QUARANTINE.

QUARANTINE applies to the detention of ships with cases of infectious diseases on board to the ports in which they are found, to the detention of persons in infected localities, and to the detention of the occupants of a house in which there is a case of infectious disease. The first is commonly spoken of as maritime quarantine, the detention of persons in infected localities as inland quarantine, and the last as house quarantine.

Maritime Quarantine.—Maritime quarantine consists of the detention of the infected ship, the isolation of the sick in a special hospital at the quarantine station, the disinfection of the ship and its cargo as well as the clothing and bedding of the well, the detention of all well persons in barracks until after the period of incubation of the particular disease has elapsed and all danger of dissemination has been eliminated. The period of detention, the mode of disinfection, as well as all the other prophylactic measures employed, will depend entirely upon the character of the disease, its period of incubation, and the nature of the ship's cargo. The disinfecting agents commonly employed are superheated steam and formaldehyd.

The following States still maintain quarantine stations in addition to the stations of the Public Health Service: Massachusetts, New York, Maryland, and Texas. In all the other States having sea, lake, or gulf ports the quarantine regulations are in charge of the Public Health Service of the United States.

The United States maintains quarantine stations at the following points: East Port and Portland, Me.; Provi-

dence, R. I.; Perth Amboy, N. J.; Reedy Island and Delaware Breakwater, Del.; Alexandria and Cape Charles, Va.; Washington, Newbern, and Cape Fear, N. C.; Charleston, Georgetown, Beaufort, and Port Royal, S. C.; Savannah and Brunswick, Ga.; Cumberland Sound, St. John's River, Biscayne Bay, Key West, Punta Rossa, Bocogrande, Tampa Bay, St. Andrew, St. Joseph, Port Inglis, Cedar Keys, St. George's Sound, and Pensacola, Fla.; Fort Morgan, Ala.; Gulf and Pascogoula, Miss.; New Orleans, La.; Laredo, Eagle Pass, and El Paso, Tex.; San Diego, San Pedro, Redondo, Santa Barbara, Port Harford, Monterey, San Francisco, Fort Bragg, and Eureka, Cal.; Columbia River, Florence, Newport, Coos Bay, Ore.; Port Townsend and Port Angles, Wash.

Inland Quarantine.—Inland quarantine is employed in times of epidemics confined to certain localities of the country. In the United States this form of quarantine has been frequently applied to localities infected with yellow fever. The prevention of all communication with the locality is sometimes enforced by a line of guards surrounding the locality, and hence is frequently spoken of as "shotgun" quarantine. Where important railroad centers are involved in an infected area, this form of quarantine is commonly known as railroad quarantine, and all intercourse with the infected area by rail is stopped. All merchandise and mail coming from the infected area are disinfected whenever traffic is not completely at a standstill.

The extension of inland quarantine to interstate commerce and traffic is known as interstate quarantine, and becomes necessary where large areas are infected and there is danger of general dissemination of the infectious disease. The establishment of definite interstate quarantine regulations by the U. S. Treasury department obviates in large part the confusion which frequently existed during an epidemic of yellow fever, because of the conflicting, and in many instances ridiculous, quar-

antine regulations formulated by State, county, and municipal authorities.

Isolation or House Quarantine.— The infectious diseases against which house quarantine is usually employed are small-pox, scarlet fever, diphtheria, cerebrospinal meningitis, cholera, typhus and typhoid fevers, yellow fever, relapsing fever, plague, poliomyelitis, and leprosy.

The patient suffering from any of these infectious diseases should be isolated from the rest of the family, preferably in a room on an upper floor of the house. All persons residing in the house are prohibited from attending any school whatsoever, as well as from going to any other places of public assembly. No one is allowed to enter the house during the course of the disease except those in direct charge of the patient, and no one is permitted to visit the sick-room except the physicians and attendants. The house is placarded by the local health authorities with a placard indicating the nature of the disease and the danger of communicating the disease to others. The placard is not removed by the health authorities until after the patient has either recovered or died, and the premises have been thoroughly disinfected.

Value of Disinfection and Isolation.—It is impossible to give definite information with regard to the value of disinfection alone, because at the present time it is almost always practised along with isolation. The value of these measures in such a disease as small-pox is well known. In other diseases they are no doubt of equal value. The only figures obtainable which bear directly upon this point are contained in the reports of the State Board of Health of Michigan. In the report for the year 1898 are given some comparative observations made during a number of outbreaks of diphtheria and scarlet fever in that State during the eleven years from 1887 to and including 1898. In some of these outbreaks isolation and disinfection were enforced, in others they were

TABLE I.—*Diphtheria.*—Exhibiting for the eleven years, 1887–97, the Number of Reported Outbreaks, Cases, and Deaths; also for this eleven-year period the average number of cases and deaths, per outbreak, in all outbreaks in which isolation or disinfection was doubtful; in which both isolation and disinfection were neglected; in which both isolation and disinfection were enforced; and also the number of cases and deaths indicated to have been prevented by isolation and disinfection.

Years.	All outbreaks.			Isolation and disinfection, or both, not mentioned, or statements doubtful.			Isolation and disinfection both neglected.			Isolation and disinfection both enforced.			Indicated saving of cases and lives by isolation and disinfection.	
	Out-breaks.	Cases.	Deaths.	Out-breaks.	Cases.	Deaths.	Out-breaks.	Cases.	Deaths.	Out-breaks.	Cases.	Deaths.	Cases.	Deaths.
1887	398	2,321	561	202	732	190	60	822	195	79	198	51	3,132	733
1888	311	1,529	324	199	810	189	34	527	81	58	101	31	3,292	416
1889	376	1,986	418	254	1,314	280	41	478	108	63	98	14	2,398	570
1890	439	2,713	619	291	1,649	401	71	902	169	46	70	15	2,862	426
1891	532	2,965	643	366	1,777	389	79	944	194	70	157	33	3,392	666
1892	525	3,485	740	323	2,341	456	52	957	147	49	105	24	3,146	746
1893	536	3,133	746	303	1,681	362	74	1,020	282	65	159	45	4,253	1,296
1894	420	2,262	404	202	986	174	56	738	122	81	176	37	3,274	512
1895	388	2,292	425	178	1,102	209	45	610	119	70	146	28	2,969	599
1896	405	2,460	432	153	925	165	64	794	142	69	164	27	2,566	467
1897	464	2,838	497	165	916	137	100	1,366	252	93	225	46	3,500	672
Totals for 11 yrs. 1887–97.	4,794	27,984	5,809	2,636	14,233	2,952	676	8,858	1,811	742	1,599	351	34,784	7,103
Average for the 11 yrs. 1887–97.	436	2,544	528	240	1,294	268	61	805	165	67	145	32	3,162	646
Average cases and deaths, per outbreak, for the 11 yrs. 1887–97.		5.83	1.21		5.39	1.12		13.20	2.70		2.16	0.48		

TABLE. II.—*Scarlet Fever.*—Exhibiting for the eleven years, and for each of the eleven years, 1887–97, the Number of Reported Outbreaks, Cases, and Deaths; also for this eleven-year period the average number of cases and deaths, per outbreak, in all outbreaks; in those outbreaks in which isolation or disinfection or both were doubtful; isolation and disinfection both neglected; isolation and disinfection both enforced; and also the number of cases and deaths indicated as having been prevented by isolation and disinfection.

Years.	All outbreaks.			Isolation or disinfection, or both, not mentioned, or statements doubtful.			Isolation and disinfection both neglected.			Isolation and disinfection both enforced.			Cases and deaths indicated as having been prevented by isolation and disinfection.	
	Outbreaks.	Cases.	Deaths.	Outbreaks.	Cases.	Deaths.	Outbreaks.	Cases.	Deaths.	Outbreaks.	Cases.	Deaths.	Cases.	Deaths.
1887	299	1,882	141	190	1,200	93	32	440	34	64	148	11	2,229	176
1888	340	1,838	112	225	955	74	61	724	33	36	80	3	2,198	72
1889	417	1,822	123	284	1,455	61	72	1,208	48	52	140	10	4,175	156
1890	477	3,054	115	302	1,711	67	94	1,137	36	42	76	1	2,718	66
1891	602	4,936	193	380	3,012	91	141	1,704	66	42	107	1	2,342	90
1892	622	5,240	306	377	2,944	188	110	1,621	59	42	97	7	3,928	30
1893	667	5,219	327	387	3,197	204	124	1,511	99	60	157	8	2,912	207
1894	662	4,349	175	378	2,366	93	104	1,348	42	74	187	9	4,231	90
1895	555	2,905	85	.275	1,259	42	82	1,139	27	92	162	4	4,798	98
1896	389	1,534	42	148	485	15	80	681	16	78	153	4	1,776	36
1897	336	1,531	52	130	654	21	63	427	17	59	127	5	747	39
Totals	5,366	35,310	1,671	3,076	19,236	949	963	11,939	477	641	1,434	63	31,228	1,012
Average, 11 years.	488	3,210	152	280	1,749	86	88	1,085	43	58	130	6	2,914	96
Average cases and deaths, per outbreak, for 11 yrs. 1887–97.		6.58	0.31		6.25	0.31		12.40	0.50		2.24	0.10		

neglected. The detailed results are given in Tables I. and II., and are also graphically presented in Chart I.

These studies indicate that 34,784 cases and 7103 deaths were saved from diphtheria, and 31,228 cases and 1012 deaths from scarlet fever, during the eleven years. If we take into consideration the immense financial saving alone that is represented by these figures, we see the great economic value to the State of the application of these preventive measures, a large part of which can no doubt be safely attributed to the employment of disinfectants.

The value of isolation and disinfection as usually practised is shown graphically in the following chart, reproduced from the proceedings of the third annual conference of the health officers of Michigan, 1896:

Isolation and Disinfection in Scarlet Fever and Diphtheria in Michigan during the Five Years 1886–90.

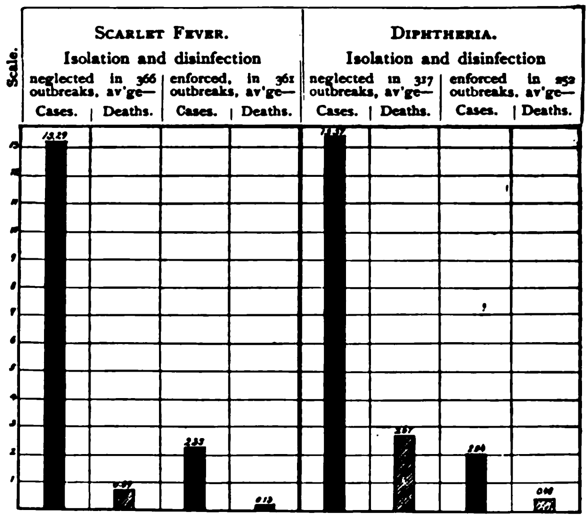


Figure 63 represents influence of isolation and disinfection in scarlet fever according to recent experience in England.[1]

[1] *Jour. of Hygiene*, vol. i., 1901.

Period of Isolation.—The period of time during which the infectiveness of a patient continues varies with each disease. In the exanthemata the quarantine is usually raised two weeks after the eruption has entirely disappeared, except for small-pox, for which the period of isolation is thirty days. In diphtheria the quarantine

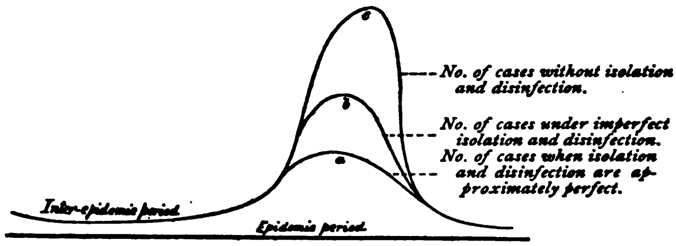


FIG. 63.—Isolation and disinfection in scarlet fever.

is not raised until cultures taken from the throat of the patient fail to show the presence of the diphtheria bacillus. This period varies very greatly in different cases, ranging from five to one hundred or more days after the total disappearance of the membrane.

Period of Detention of Those Exposed to the Infectious Diseases.—Those exposed to the infectious diseases are detained until after the period of incubation of the particular disease has elapsed. The following table shows the period of incubation of the more common infectious diseases:

Small-pox	12 days.
Measles	10 "
Scarlet fever	3 "
Diphtheria	3 "
Cholera	10 "
Typhoid fever	14 "
Yellow fever	5 "

If no new outbreaks occur during the period of detention among those who have been exposed to the infection, the quarantine is raised after the period of incubation of the particular disease has elapsed.

Maritime Quarantine.—Maritime quarantine is practised against cholera, typhus fever, yellow fever, small-pox, leprosy, and plague, though any of the acute infectious diseases may be quarantined.

In a recent paper on modern quarantine in Canada and the United States, Dr. Montizambert, of Quebec, states that the requirements for a quarantine station are held to be as follows:

"1. A boarding station, so placed as to command the channel leading to the port.

"2. A boarding steamer fitted with hospital cabins, for landing the sick, and with appliances for disinfecting in the offing ships' hospitals with mercuric chlorid douche, and with steam when such disinfection is found to be all that the vessel requires.

"3. A reserve steamer to replace the usual boarding steamer on emergency, and—where the station is isolated—to act as a supply and mail steamer, for forwarding convalescents, etc.

"4. An anchorage for vessels under quarantine or observation. It should be placed conveniently for the main establishment, and safely remote from the track of commerce.

"5. A deep-water pier. The depth of water at low tide at its end should be at least equal to the draught of the largest vessels coming to the port, with a frontage sufficient for such vessels to moor to it if required. Upon this pier there should be constructed—

"*a.* A warehouse;

"*b.* Elevated tanks for disinfecting solutions;

"*c.* A disinfecting-house containing steam disinfecting cylinders;

"*d.* Sulphur furnace, engine, exhaust fans, etc., for fumigation.

"6. A lazarette or hospital for the treatment of infectious diseases.

"7. Separate accommodations for non-infectious cases from infected vessels in quarantine.

"8. Detention-houses for the detention, under observation, in groups, of "suspects" or persons who have been exposed to infection.

"9. Quarters for officers and staff.

"10. Telegraphic communication with the rest of the world. Telephonic communication between the different parts of the station.

"11. A bacteriologic laboratory.

"12. A cremation furnace for the disposal of the bodies of those who have died of infectious diseases."

Within the last few years most of the quarantine stations have been equipped with formaldehyd gas generators for use in the disinfection of infected vessels.

All maritime and interstate quarantine powers of the United States have been conferred upon the Supervising Surgeon-General of the Public Health and Marine-Hospital Service, and this service is under the direction of the Secretary of the Treasury. The following is a transcript of the acts of Congress conferring these powers, as well as the quarantine laws of the United States:

QUARANTINE LAWS OF THE UNITED STATES.

AN ACT TO INCREASE THE EFFICIENCY AND CHANGE THE NAME OF THE UNITED STATES MARINE-HOSPITAL SERVICE.

[Approved July 1, 1902.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the United States Marine-Hospital Service shall hereafter be known and designated as the Public Health and Marine-Hospital Service of the United States, and the Supervising Surgeon-General and the officers now or hereafter commissioned under the Act of January fourth, eighteen hundred and eighty-nine, entitled "An Act to regulate appointments in the Marine-Hospital Service of the United States," and Acts amendatory thereof, shall hereafter be known as the Surgeon-General, surgeons, passed assistant surgeons, and assistant surgeons of the Public Health and Marine-Hospital Service of the United States. Nothing in this Act contained shall be held or construed to discharge any of the officers above named, or any of the acting assistant surgeons, pharmacists, and other employees of the Marine-Hospital Service, or to deprive

any officer of his commission or the benefits derived by longevity of service. The care of sick and disabled seamen and all other duties now required by law to be performed by the Marine-Hospital Service shall hereafter be performed by the Public Health and Marine-Hospital Service, and all funds and appropriations now provided by law for use by the Marine-Hospital Service and all properties and rights pertaining to said service shall be available for use for like purposes and in like manner, under the Treasury Department, by the Public Health and Marine-Hospital Service.

SEC. 2. That the salary of the Surgeon-General of the Public Health and Marine-Hospital Service shall be five thousand dollars per annum, and the salaries and allowances of the commissioned medical officers of said service shall be the same as now provided by regulations of the Marine-Hospital Service.

SEC. 3. That commissioned medical officers, when detailed by the Surgeon-General for duty in the Public Health and Marine-Hospital Bureau at Washington, District of Columbia, in charge of the administrative divisions thereof, namely, marine hospitals and relief, domestic quarantine, foreign and insular quarantine, personnel and accounts, sanitary reports and statistics, and scientific research, shall, while thus serving, be assistant surgeons-general of the Public Health and Marine-Hospital Service, but their pay and allowances shall be the same as now provided by regulations of the Marine-Hospital Service for officers in charge of said divisions; and the senior officer thus serving shall be the assistant within the meaning of section one hundred and seventy-eight, Revised Statutes of the United States: *Provided, however,* That no such officer shall be detailed in charge of said divisions who is below the rank of passed assistant surgeon.

SEC. 4. That the President is authorized, in his discretion, to utilize the Public Health and Marine-Hospital Service in times of threatened or actual war to such extent and in such manner as shall in his judgment promote the public interest without, however, in any wise impairing the efficiency of the service for the purposes for which the same was created and is maintained.

SEC. 5. That there shall be an advisory board for the hygienic laboratory provided by the Act of Congress approved March third, nineteen hundred and one, for consultation with the Surgeon-General of the Public Health and Marine-Hospital Service relative to the investigations to be inaugurated, and the methods of conducting the same, in said laboratory. Said board shall consist of three competent experts, to be detailed from the Army, the Navy, and the Bureau of Animal Industry by the Surgeon-General of the Army, the Surgeon-General of the Navy, and the Secretary of Agriculture, respectively, which experts, with the director of the said laboratory, shall be ex officio members of the board, and serve without additional compensation. Five other members of said board shall be appointed by the Surgeon-Ger

eral of Public Health and Marine-Hospital Service, with the approval of the Secretary of the Treasury, who shall be skilled in laboratory work in its relation to the public health, and not in the regular employment of the Government. The said five members shall each receive compensation of ten dollars per diem while serving in conference, as aforesaid, together with allowance for actual and necessary traveling expenses and hotel expenses while in conference. Said conference is not to exceed ten days in any one fiscal year. The term of service of the five members of said board, not in the regular employment of the Government, first appointed shall be so arranged that one of said members shall retire each year, the subsequent appointments to be for a period of five years. Appointments to fill vacancies occurring in a manner other than as above provided shall be made for the unexpired term of the member whose place has become vacant.

SEC. 6. That there shall be appointed by the Surgeon-General, with the approval of the Secretary of the Treasury, whenever, in the opinion of the Surgeon-General, commissioned medical officers of the Public Health and Marine-Hospital Service are not available for this duty by detail, competent persons to take charge of the divisions, respectively, of chemistry, zoology, and pharmacology of the hygienic laboratory, who shall each receive such pay as shall be fixed by the Surgeon-General, with the approval of the Secretary of the Treasury. The director of the said laboratory shall be an officer detailed from the corps of commissioned medical officers of the Public Health and Marine-Hospital Service, as now provided by regulations for said detail from the Marine-Hospital Service, and while thus serving shall have the pay and emoluments of a surgeon: *Provided*, That all commissioned officers of the Public Health and Marine-Hospital Service not below the grade of passed assistant surgeon shall be eligible to assignment to duty in charge of the said divisions of the hygienic laboratory, and while serving in such capacity shall be entitled to the pay and emoluments of their rank.

SEC. 7. That when, in the opinion of the Surgeon-General of the Public Health and Marine-Hospital Service of the United States, the interests of the public health would be promoted by a conference of said service with State or Territorial boards of health, quarantine authorities, or State health officers, the District of Columbia included, he may invite as many of said health and quarantine authorities as he deems necessary or proper to send delegates, not more than one from each State or Territory and District of Columbia, to said conference: *Provided*, That an annual conference of the health authorities of all the States and Territories and the District of Columbia shall be called, each of said States, Territories, and the District of Columbia to be entitled to one delegate: *And provided, further*, That it shall be the duty of the said Surgeon-General to call a conference upon the application of not less than five State or Territorial boards of

health, quarantine authorities, or State health officers, each of said States and Territories joining in such request to be represented by one delegate.

SEC. 8. That to secure uniformity in the registration of mortality, morbidity, and vital statistics it shall be the duty of the Surgeon-General of the Public Health and Marine-Hospital Service, after the annual conference required by section seven to be called, to prepare and distribute suitable and necessary forms for the collection and compilation of such statistics, and said statistics, when transmitted to the Public Health and Marine-Hospital Bureau on said forms, shall be compiled and published by the Public Health and Marine-Hospital Service as a part of the health reports published by said service.

SEC. 9. That the President shall from time to time prescribe rules for the conduct of the Public Health and Marine-Hospital Service. He shall also prescribe regulations respecting its internal administration and discipline, and the uniforms of its officers and employees. It shall be the duty of the Surgeon-General to transmit annually to the Secretary of the Treasury, for transmission by said Secretary to Congress, a full and complete report of the transactions of said service, including a detailed statement of receipts and disbursements.

AN ACT GRANTING ADDITIONAL QUARANTINE POWERS AND IMPOSING ADDITIONAL DUTIES UPON THE MARINE-HOSPITAL SERVICE.

[Approved, February 15, 1893.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That it shall be unlawful for any merchant ship or other vessel from any foreign port or place of [to] enter any port of the United States except in accordance with the provisions of this act and with such rules and regulations of State and municipal health authorities as may be made in pursuance of, or consistent with, this act; and any such vessel which shall enter, or attempt to enter, a port of the United States in violation thereof shall forfeit to the United States a sum, to be awarded in the discretion of the court, not exceeding five thousand dollars, which shall be a lien upon said vessel, to be recovered by proceedings in the proper district court of the United States. In all such proceedings the United States district attorney for such district shall appear on behalf of the United States; and all such proceedings shall be conducted in accordance with the rules and laws governing cases of seizure of vessels for violation of the revenue laws of the United States.

SEC. 2. That any vessel at any foreign port clearing for any port or place in the United States shall be required to obtain from the consul, vice-consul, or other consular officer of the United States at the port of departure, or from the medical officer where such officer has been detailed by the President for th

purpose, a bill of health, in duplicate, in the form prescribed by the Secretary of the Treasury, setting forth the sanitary history and condition of said vessel, and that it has in all respects complied with the rules and regulations in such cases prescribed for securing the best sanitary condition of the said vessel, its cargo, passengers, and crew; and said consular or medical officer is required, before granting such duplicate bill of health, to be satisfied that the matters and things therein stated are true; and for his services in that behalf he shall be entitled to demand and receive such fees as shall by lawful regulation be allowed, to be accounted for as is required in other cases.

The President, in his discretion, is authorized to detail any medical officer of the Government to serve in the office of the consul at any foreign port for the purpose of furnishing information and making the inspection and giving the bills of health hereinbefore mentioned. Any vessel clearing and sailing from any such port without such bill of health, and entering any port of the United States, shall forfeit to the United States not more than five thousand dollars, the amount to be determined by the court, which shall be a lien on the same, to be recovered by proceedings in the proper district court of the United States. In all such proceedings the United States district attorney for such district shall appear on behalf of the United States; and all such proceedings shall be conducted in accordance with the rules and laws governing cases of seizure of vessels for violation of the revenue laws of the United States.

SEC. 3. That the Supervising Surgeon-General of the Marine-Hospital Service shall, immediately after this act takes effect, examine the quarantine regulations of all State and municipal boards of health, and shall, under the direction of the Secretary of the Treasury, coöperate with and aid State and municipal boards of health in the execution and enforcement of the rules and regulations of such boards and in the execution and enforcement of the rules and regulations made by the Secretary of the Treasury, to prevent the introduction of contagious or infectious diseases into the United States from foreign countries, and into one State or Territory or the District of Columbia from another State or Territory or the District of Columbia; and all rules and regulations made by the Secretary of the Treasury shall operate uniformly and in no manner discriminate against any port or place; and at such ports and places within the United States as have no quarantine regulations under State or municipal authority, where such regulations are, in the opinion of the Secretary of the Treasury, necessary to prevent the introduction of contagious or infectious diseases into the United States from foreign countries, or into one State or Territory or the District of Columbia from another State or Territory or the District of Columbia, and at such ports and places within the United States where quarantine regulations exist under the

authority of the State or municipality which, in the opinion of the Secretary of the Treasury, are not sufficient to prevent the introduction of such diseases into the United States, or into one State or Territory or the District of Columbia from another State or Territory or the District of Columbia, the Secretary of the Treasury shall, if in his judgment it is necessary and proper, make such additional rules and regulations as are necessary to prevent the introduction of such diseases into the United States from foreign countries, or into one State or Territory or the District of Columbia from another State or Territory or the District of Columbia, and when said rules and regulations have been made they shall be promulgated by the Secretary of the Treasury and enforced by the sanitary authorities of the States and municipalities, where the State or municipal health authorities will undertake to execute and enforce them; but if the State or municipal authorities shall fail or refuse to enforce said rules and regulations, the President shall execute and enforce the same and adopt such measures as in his judgment shall be necessary to prevent the introduction or spread of such diseases, and may detail or appoint officers for that purpose. The Secretary of the Treasury shall make such rules and regulations as are necessary to be observed by vessels at the port of departure and on the voyage, where such vessels sail from any foreign port or place to any port or place in the United States, to secure the best sanitary condition of such vessel, her cargo, passengers, and crew; which shall be published and communicated to and enforced by the consular officers of the United States. None of the penalties herein imposed shall attach to any vessel or owner or officer thereof until a copy of this act, with the rules and regulations made in pursuance thereof, has been posted up in the office of the consul or other consular officer of the United States for ten days, in the port from which said vessel sailed; and the certificate of such consul or consular officer over his official signature shall be competent evidence of such posting in any court of the United States.

SEC. 4. That it shall be the duty of the Supervising Surgeon-General of the Marine-Hospital Service, under the direction of the Secretary of the Treasury, to perform all the duties in respect to quarantine and quarantine regulations which are provided for by this act, and to obtain information of the sanitary condition of foreign ports and places from which contagious and infectious diseases are or may be imported into the United States, and to this end the consular officers of the United States at such ports and places as shall be designated by the Secretary of the Treasury shall make to the Secretary of the Treasury weekly reports of the sanitary condition of the ports and places at which they are respectively stationed, according to such forms as the Secretary of the Treasury shall prescribe; and the Secretary of the Treasury shall also obtain, through all sources accessible, including State and municipal sanitary authorities throughout the United

States, weekly reports of the sanitary condition of ports and places within the United States, and shall prepare, publish, and transmit to collectors of customs and to State and municipal health officers and other sanitarians weekly abstracts of the consular sanitary reports and other pertinent information received by him, and shall also, as far as he may be able, by means of the voluntary coöperation of State and municipal authorities, of public associations, and private persons, procure information relating to the climatic and other conditions affecting the public health, and shall make an annual report of his operations to Congress, with such recommendations as he may deem important to the public interests.

SEC. 5. That the Secretary of the Treasury shall from time to time issue to the consular officers of the United States and to the medical officers serving at any foreign port, and otherwise make publicly known, the rules and regulations made by him, to be used and complied with by vessels in foreign ports, for securing the best sanitary condition of such vessels, their cargoes, passengers, and crew, before their departure for any port in the United States, and in the course of the voyage; and all such other rules and regulations as shall be observed in the inspection of the same on the arrival thereof at any quarantine station at the port of destination, and for the disinfection and isolation of the same, and the treatment of cargo and persons on board, so as to prevent the introduction of cholera, yellow fever, or other contagious or infectious diseases; and it shall not be lawful for any vessel to enter said port to discharge its cargo, or land its passengers, except upon a certificate of the health officer at such quarantine station certifying that said rules and regulations have in all respects been observed and complied with, as well on his part as on the part of the said vessel and its master, in respect to the same and to its cargo, passengers, and crew; and the master of every such vessel shall produce and deliver to the collector of customs at said port of entry, together with the other papers of the vessel, the said bills of health required to be obtained at the port of departure and the certificate herein required to be obtained from the health officer at the port of entry; and that the bills of health herein prescribed shall be considered as part of the ship's papers, and when duly certified to by the proper consular officer or other officer of the United States, over his official signature and seal, shall be accepted as evidence of the statements therein contained in any court of the United States.

SEC. 6. That on the arrival of an infected vessel at any port not provided with proper facilities for treatment of the same, the Secretary of the Treasury may remand said vessel, at its own expense, to the nearest national or other quarantine station, where accommodations and appliances are provided for the necessary disinfection and treatment of the vessel, passengers, and cargo; and after treatment of any infected vessel at a national

quarantine station, and after certificate shall have been given by the United States quarantine officer at said station that the vessel, cargo, and passengers are each and all free from infectious disease, or danger of conveying the same, said vessel shall be admitted to entry to any port of the United States named within the certificate. But at any ports where sufficient quarantine provision has been made by State or local authorities the Secretary of the Treasury may direct vessels bound for said ports to undergo quarantine at said State or local station.

SEC. 7. That whenever it shall be shown to the satisfaction of the President that by reason of the existence of cholera or other infectious or contagious diseases in a foreign country there is serious danger of the introduction of the same into the United States, and that notwithstanding the quarantine defence this danger is so increased by the introduction of persons or property from such country that a suspension of the right to introduce the same is demanded in the interest of the public health, the President shall have power to prohibit, in whole or in part, the introduction of persons and property from such countries or places as he shall designate and for such period of time as he may deem necessary.

SEC. 8. That whenever the proper authorities of a State shall surrender to the United States the use of the buildings and disinfecting apparatus at a State quarantine station the Secretary of the Treasury shall be authorized to receive them and to pay a reasonable compensation to the State for their use, if, in his opinion, they are necessary to the United States.

SEC. 9. That the act entitled "An act to prevent the introduction of infectious or contagious diseases into the United States, and to establish a national board of health," approved March 3, 1879, be, and the same is hereby, repealed. And the Secretary of the Treasury is directed to obtain possession of any property, furniture, books, paper, or records belonging to the United States which are not in the possession of an officer of the United States under the Treasury Department which were formerly in the use of the National Board of Health or any officer or employé thereof.

[Act of Congress, approved August 18, 1894.]

AN ACT to amend section two of the act approved February fifteenth, eighteen hundred and ninety-three, entitled "An act granting additional quarantine powers and imposing additional duties upon the Marine-Hospital Service."

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That section two of the act approved February fifteenth, eighteen hundred and ninety-three, entitled "An act granting additional quarantine powers and imposing additional duties upon the Marine-Hospital Service," is hereby amended by adding to the end of said section the following:

"The provisions of this section shall not apply to vessels plying between foreign ports on or near the frontiers of the United States and ports of the United States adjacent thereto; but the Secretary of the Treasury is hereby authorized, when, in his discretion, it is expedient for the preservation of the public health, to establish regulations governing such vessels."

REVISED STATUTES.

SEC. 4794. There shall be purchased or erected, under the orders of the President, suitable warehouses, with wharves and inclosures, where merchandise may be unladen and deposited from any vessel which shall be subject to a quarantine or other restraint, pursuant to the health laws of any State, at such convenient places therein as the safety of the public revenue and the observance of such health laws may require.

SEC. 4795. Whenever the cargo of a vessel is unladen at some other place than the port of entry or delivery under the foregoing provisions, all the articles of such cargo shall be deposited, at the risk of the parties concerned therein, in such public or other warehouses or inclosures as the collector shall designate, there to remain under the joint custody of such collector and of the owner, or master, or other person having charge of such vessel, until the same are entirely unladen or discharged, and until the articles so deposited may be safely removed without contravening such health laws. And when such removal is allowed, the collector having charge of such articles may grant permits to the respective owners or consignees, their factors or agents, to receive all merchandise which has been entered, and the duties accruing upon which have been paid, upon the payment by them of a reasonable rate of storage; which shall be fixed by the Secretary of the Treasury for all public warehouses and inclosures.

SEC. 4796. The Secretary of the Treasury is authorized, whenever a conformity to such quarantine and health laws requires it, and in respect to vessels subject thereto, to prolong the terms limited for the entry of the same and the report or entry of their cargoes, and to vary or dispense with any other regulations applicable to such reports or entries. No part of the cargo of any vessel shall, however, in any case be taken out or unladen therefrom otherwise than is allowed by law, or according to the regulations hereinafter established.

SEC. 4797. Whenever, by the prevalence of any contagious or epidemic disease in or near the place by law established as the port of entry for any collection district, it becomes dangerous or inconvenient for the officers of the revenue employed therein to continue the discharge of their respective offices at such port, the Secretary of the Treasury, or, in his absence, the First Comptroller, may direct the removal of the officers of the revenue

from such port to any other more convenient place within or as near as may be to such collection district. And at such place such officers may exercise the same powers and shall be liable to the same duties, according to existing circumstances, as in the port or district established by law. Public notice of any such removal shall be given as soon as may be.

SEC. 4798. In case of the prevalence of a contagious or epidemic disease at the seat of Government, the President may permit and direct the removal of any or all the public offices to such other place or places as he shall deem most safe and convenient for conducting the public business.

SEC. 4799. Whenever, in the opinion of the Chief Justice, or, in case of his death or inability, of the senior associate justice, of the Supreme Court, a contagious or epidemic sickness shall render it hazardous to hold the next stated session of the court at the seat of Government, the chief or such associate justice may issue his order to the marshal of the Supreme Court, directing him to adjourn the next session of the court to such other place as such justice deems convenient. The marshal shall thereupon adjourn the court by making publication thereof in one or more public papers printed at the seat of Government from the time he shall receive such order until the time by law prescribed for commencing the session. The several circuit and district judges shall, respectively, under the same circumstances, have the same power, by the same means, to direct adjournments of the several circuit and district courts to some convenient place within their districts, respectively.

SEC. 4800. The judge of any district court within whose district any contagious or epidemic disease shall at any time prevail, so as, in his opinion, to endanger the lives of persons confined in the prison of such district, in pursuance of any law of the United States, may direct the marshal to cause the persons so confined to be removed to the next adjacent prison where such disease does not prevail, there to be confined until they may safely be removed back to the place of their first confinement. Such removals shall be at the expense of the United States.

SEC. 4263. The master of any vessel employed in transporting passengers between the United States and Europe is authorized to maintain good discipline and such habits of cleanliness among the passengers as will tend to the preservation and promotion of health, and to that end he shall cause such regulations as he may adopt for this purpose to be posted up, before sailing, on board such vessel, in a place accessible to such passengers, and shall keep the same so posted up during the voyage. Such master shall cause the apartments occupied by such passengers to be kept at all times in a clean, healthy state; and the owners of every such vessel so employed are required to construct the decks and all parts of the apartments so that they can be thoroughly cleansed, and also to provide a safe, convenient privy, or

water-closet, for the exclusive use of every one hundred such passengers. The master shall also, when the weather is such that the passengers can not be mustered on deck with their bedding, and at such other times as he may deem necessary, cause the deck occupied by such passengers to be cleansed with chlorid of lime or some other equally efficient disinfecting agent. And for each neglect or violation of any of the provisions of this section the master and owner of any such vessel shall be severally liable to the United States in a penalty of fifty dollars, to be recovered in any circuit or district court within the jurisdiction of which such vessel may arrive or from which she is about to depart, or at any place where the owner or master may be found.

[Extract from act August 1, 1888.]

Whenever any person shall trespass upon the grounds belonging to any quarantine reservation, such person, trespassing, shall, upon conviction thereof, pay a fine of not more than three hundred dollars, or be sentenced to imprisonment for a period of not more than thirty days, or shall be punished by both fine and imprisonment, at the discretion of the court. And it shall be the duty of the United States Attorney in the district where the misdemeanor shall have been committed to take immediate cognizance of the offence, upon report made to him by any medical officer of the Marine-Hospital Service, or by any officer of the customs service, or by any State officer acting under authority of section five of said act.

AN ACT TO PREVENT THE INTRODUCTION OF CONTAGIOUS DISEASES FROM ONE STATE TO ANOTHER AND FOR THE PUNISHMENT OF CERTAIN OFFENCES.

[Act March 27, 1890.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That whenever it shall be made to appear to the satisfaction of the President that cholera, yellow fever, small-pox, or plague exists in any State or Territory, or in the District of Columbia, and that there is danger of the spread of such disease into other States, Territories, or the District of Columbia, he is hereby authorized to cause the Secretary of the Treasury to promulgate such rules and regulations as in his judgment may be necessary to prevent the spread of such disease from one State or Territory into another, or from any State or Territory into the District of Columbia, or from the District of Columbia into any State or territory, and to employ such inspectors and other persons as may be necessary to execute such regulations to prevent the spread of such disease. The said rules and regulations shall be prepared by the Supervising Surgeon-General of the Marine-Hospital Service under the direction of the Secre-

tary of the Treasury. And any person who shall willfully violate any rule or regulation so made and promulgated shall be deemed guilty of a misdemeanor, and upon conviction shall be punished by a fine of not more than five hundred dollars, or imprisonment for not more than two years, or both, in the discretion of the court.

SEC. 2. That any officer, or person acting as an officer, or agent of the United States at any quarantine station, or other person employed to aid in preventing the spread of such disease, who shall willfully violate any of the quarantine laws of the United States, or any of the rules and regulations made and promulgated by the Secretary of the Treasury as provided for in Section 1 of this act, or any lawful order of his superior officer or officers, shall be deemed guilty of a misdemeanor, and upon conviction shall be punished by a fine of not more than three hundred dollars or imprisonment for not more than one year, or both, in the discretion of the court.

SEC. 3. That when any common carrier or officer, agent, or employé of any common carrier shall willfully violate any of the quarantine laws of the United States, or the rules and regulations made and promulgated as provided for in Section 1 of this act, such common carrier, officer, agent, or employé shall be deemed guilty of a misdemeanor, and shall, on conviction, be punished by a fine of not more than five hundred dollars, or imprisonment for not more than two years, or both, in the discretion of the court.

AN ACT TO AMEND "AN ACT GRANTING ADDITIONAL QUARANTINE POWER AND IMPOSING ADDITIONAL DUTIES UPON THE MARINE HOSPITAL SERVICE," APPROVED FEBRUARY FIFTEENTH, EIGHTEEN HUNDRED AND NINETY-THREE.

[Act March 2, 1901.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That an Act granting additional quarantine powers and imposing additional duties upon the Marine-Hospital Service, approved February fifteenth, eighteen hundred and ninety-three, be amended by addition of the following sections:

"SEC. 10. That the Supervising Surgeon-General, with the approval of the Secretary of the Treasury, is authorized to designate and mark the boundaries of the quarantine grounds and quarantine anchorages for vessels which are reserved for use at each United States quarantine station; and any vessel or officer of any vessel or other person, other than State or municipal health or quarantine officers, trespassing or otherwise entering upon such grounds or anchorages in disregard of the quarantine rules and regulations, or without permission of the officer in charge of such station, shall be deemed guilty of a misdemeanor and subject to arrest, and upon conviction thereof be punished by a fine of not more than three hundred dollars or imprisonment for

not more than one year, or both, in the discretion of the court. Any master or owner of any vessel, or any person violating any provision of this Act or any rule or regulation made in accordance with this Act, relating to inspection of vessels or relating to the prevention of the introduction of contagious or infectious diseases, or any master, owner, or agent of any vessel making a false statement relative to the sanitary condition of said vessel or its contents or as to the health of any passenger or person thereon, shall be deemed guilty of a misdemeanor and subject to arrest, and upon conviction thereof be punished by a fine of not more than five hundred dollars or imprisonment for not more than one year, or both, in the discretion of the court.

"SEC. 11. That any vessel sailing from any foreign port without the bill of health required by section two of this Act, and arriving within the limits of any collection district of the United States, and not entering or attempting to enter any port of the United States, shall be subject to such quarantine measures as shall be prescribed by regulations of the Secretary of the Treasury, and the cost of such measures shall be a lien on said vessel, to be recovered by proceedings in the proper district court of the United States and in the manner set forth above as regards vessels from foreign ports without bills of health and entering any port of the United States.

"SEC. 12. That the medical officers of the United States, duly clothed with authority to act as quarantine officers at any port or place within the United States, and when performing the said duties, are hereby authorized to take declarations and administer oaths in matters pertaining to the administration of the quarantine laws and regulations of the United States."

AN ACT TO FURTHER PROTECT THE PUBLIC HEALTH AND MAKE MORE EFFECTIVE THE NATIONAL QUARANTINE.

[Approved, June 19, 1906.]

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That the Secretary of the Treasury shall have the control, direction, and management of all quarantine stations, grounds, and anchorages established by authority of the United States, and as soon as practicable after the approval of this Act shall select and designate such suitable places for them and establish the same at such points on or near the coast line of the United States or the border of the United States and a foreign country, as in his judgment are best suited for the same and necessary to prevent the introduction of yellow fever into the United States, and, in his discretion, he may also establish at the group of islands known as the Dry Tortugas, at the western end of the Florida reef, and at such other point or points on or near the coast line of the United States (not to exceed four in the aggre-

gate) as he deems necessary, quarantine grounds, stations, and anchorages, whereat or whereto infected vessels bound for any port in the United States may be detained or sent for the purpose of being disinfected, having their cargoes disinfected and discharged, if necessary, and their sick treated in hospitals until all danger of infection or contagion from such vessels, their cargoes, passengers, or crews has been removed.

SEC. 2. That in cases in which the title to the land and water so selected and designated is in the United States it shall be the duty of the department, bureau, or official of the United States having custody or possession of such land and water, or any part thereof, not used by the Government for other purposes designated by law, or possession of said Dry Tortugas Islands, on demand of the Secretary of the Treasury, to deliver the same into his custody and possession for the use of the Public Health and Marine-Hospital Service, evidencing such delivery by a suitable instrument in writing to be delivered to the Secretary of the Treasury. That in cases in which the title to such land and water, or any part thereof, is in any other owner than the United States it shall be the duty of the Secretary of the Treasury to secure the title and possession of the same to the United States for the use of the Public Health and Marine-Hospital Service of the United States, by purchase at a reasonable price, if possible; but if, in his judgment, the price demanded for such property be excessive, he is hereby authorized to apply to the Attorney-General of the United States to cause to be instituted, in the proper tribunal, condemnation proceedings in the name of the United States for the purpose of acquiring for the United States the title and possession of such land and water, and said Attorney-General shall, as soon as possible after such application by the Secretary of the Treasury, cause such proceedings to be instituted and conducted to a conclusion, and the custody and possession of such land and water, when duly acquired in accordance with the award made in such condemnation proceedings, shall be delivered to the Secretary of the Treasury for the use of the Public Health and Marine-Hospital Service.

SEC. 3. That on acquiring possession of any land and water in accordance with the provisions of this Act for the purpose of establishing thereat a quarantine station and anchorage, the Secretary of the Treasury shall cause to be published in such newspapers as he may think proper, once a week for four successive weeks, a notice of the selection and designation of such places for quarantine stations and anchorages, with a description of the boundaries of such quarantine stations and anchorages, and such rules and regulations as he shall adopt and promulgate, requiring vessels with yellow fever among their passengers or crews to go to specified quarantine stations and anchorages, to be dealt with there before visiting any port of the United States.

He shall establish at such quarantine stations and anchorages all necessary instrumentalities for disinfecting vessels and their cargoes, and where the same shall be required shall erect the necessary hospital buildings and install the necessary furniture and fittings for receiving and treating the sick among the passengers and crews of vessels going to such quarantine stations and anchorages, and provide for the separation of those among their passengers and crews who are suffering from yellow fever from those who are in good health, and shall further provide for doing all things necessary to eradicate such disease from such vessels, their cargoes, passengers, and crews.

SEC. 4. That any vessel, or any officer of any vessel, or other person other than State health or quarantine officers, entering within the limits of any quarantine grounds and anchorages, or any quarantine station and anchorage, or departing therefrom, in disregard of the quarantine rules and regulations or without the permission of the officer in charge of such quarantine ground and anchorage, or of such quarantine station and anchorage, shall be deemed guilty of a misdemeanor, and upon conviction thereof shall be punished by a fine of not more than three hundred dollars or by imprisonment for not more than one year, or both, in the discretion of the court. That any master or owner of any vessel violating any provision of this Act, or any provision of an Act entitled "An Act granting additional powers and imposing additional duties on the Marine-Hospital Service," approved February fifteenth, eighteen hundred and ninety-three, or violating any rule or regulation made in accordance with this Act or said Act of February fifteenth, eighteen hundred and ninety-three, relating to the inspection of vessels, or to the prevention of the introduction of contagious or infectious diseases into the United States, or any master, owner, or agent of any vessel making a false statement relative to the sanitary condition of such vessel or its contents, or as to the health of any passenger or person thereon shall be deemed guilty of a misdemeanor, and on conviction thereof shall be punished by a fine of not more than five hundred dollars or imprisonment for not more than one year, or both, in the discretion of the court.

SEC. 5. That in any place where a quarantine station and plant is already established by State or local authorities it shall be the duty of the Secretary of the Treasury, before selecting and designating a quarantine station and grounds and anchorage for vessels, to examine such established stations and plants, with a view of obtaining a transfer of the site and plants to the United States, and whenever the proper authorities shall be ready to transfer the same or surrender the use thereof to the United States, the Secretary of the Treasury is authorized to obtain title thereto or possession and use thereof, and to pay a reasonable compensation therefor, if, in his opinion, such pur-

chase or use will be necessary to the United States for quarantine purposes and the quarantine stations established by authority of this Act shall, when so established, be used to prevent the introduction of all quarantinable diseases.

SEC. 6. That whenever any established station, or any land or water, or any part thereof, shall be acquired by the United States under the provisions of this Act, jurisdiction over the same shall be ceded to the United States by any State in which the same is situated before any compensation therefor shall be paid.

SEC. 7. That the sum of five hundred thousand dollars, or so much thereof as may be necessary, is hereby appropriated, out of any money in the Treasury not otherwise appropriated, for the purpose of carrying into effect the provisions of this Act, as well as for the purpose generally of preventing the importation of yellow fever and other quarantinable diseases into the United States, and for the further purposes, in co-operation with State or municipal health authorities, of eradicating them should they be imported, of preventing their spread from one State into another State, and of destroying their causes.

QUARANTINE REGULATIONS.

QUARANTINABLE DISEASES.

1. For the purpose of these regulations the quarantinable diseases are cholera, yellow fever, small-pox, typhus fever, leprosy, and plague.

FOREIGN REGULATIONS.

Quarantine Regulations to be Observed at Foreign Ports and at Ports in the Possessions and Dependencies of the United States.

BILLS OF HEALTH.

2. Masters of vessels departing from any foreign port, or from any port in the possessions or other dependencies of the United States for a port in the United States or its possessions or other dependencies, must obtain a bill of health, in duplicate, signed by the proper officer or officers of the United States as provided for by law, except as provided for in paragraph 4.

The following form is prescribed:

[Form No. 1937.]

UNITED STATES OF AMERICA.

ORIGINAL BILL OF HEALTH.

I, ——— (the person authorized to issue the bill, at the port of ———), do hereby state that the vessel hereinafter named clears from the port of ——— under the following circumstances:

Name of vessel, ———. Nationality. ———. Rig. ———. Master, ———. Tonnage, gross. ———; net, ———. Iron or wood, ———. Number of compartments for cargo, ———. For steerage passengers, ———. For crew, ———.

Name of medical officer, ———.

Number of officers, ———; of crew, including petty officers, ———; of passengers, first cabin, ———; second cabin, ———; steerage, ———. Officers' families, ———. Total number of persons on board, ———.

Passengers destined for the United States, ——— first cabin, ——— second cabin, ——— steerage.

Previous port, ———.

Number of cases of sickness, and character of same, during last voyage, ———.

Number of cases of sickness, and character of same, while vessel was in this port, ———.

Vessel engaged in ——— trade, and plies between ——— and ———.

Nature, sanitary history, and condition of cargo, ———.

Source and wholesomeness of water supply, ———.

Source and wholesomeness of food supply, ———.

Sanitary history and health of officers and crew, ———.

Sanitary history and health of passengers, cabin, ———.

Sanitary history and health of passengers, steerage, ———.

Sanitary history and condition of their effects, ———.

Location of vessel while in port—wharf, ———; open bay, ———; distance from shore, ———.

Time vessel was in port, ———.

Character of communication with shore, ———.

Sanitary condition of vessel, ———.

Sanitary measures, if any, adopted while in port, ———.

Sanitary condition of port and vicinity, ———.

Prevailing diseases at port and vicinity, ———.

Malaria, ——— deaths during month of ———.

Number of cases and deaths from the following-named diseases during the past two weeks, ending ———.

Diseases.	Number of Cases.	Number of Deaths.
Yellow fever	....	....
Asiatic cholera	....	....
Cholera nostras or cholerine	....	....
Small-pox	....	....
Typhus fever	....	....
Plague	....	....
Leprosy	....	....

REMARKS.

Any conditions affecting the public health existing in the port of departure or vicinity to be here stated.

When there are no cases or deaths, entry to that effect must be made.

I certify that the vessel has complied with the Quarantine Rules and Regulations made under the act of February 15, 1893, and that the vessel leaves this port bound for ———, United States of America, via ———.

Given under my hand and seal this ——— day of ———, 191—.

(Signature of consular officer:) ——— ———;

[SEAL.] ——— ———,

3. Vessels clearing from a foreign port or from any port in the possessions or other dependencies of the United States for any port in the United States, its possessions or other dependencies, and entering or calling at intermediate ports, must procure at all said ports a supplemental bill of health in duplicate signed by the proper officer or officers of the United States, as provided in the law. If a quarantinable disease has appeared on board the vessel after leaving the original port of departure, or other circumstances presumably render the vessel infected, the supplemental bill of health should be withheld until such sanitary measures have been taken as are necessary.

The following form is prescribed:

UNITED STATES OF AMERICA.

SUPPLEMENTAL BILL OF HEALTH.

PORT OF ——.

Vessel ——, bound from —— to ——, U. S. A.
Sanitary condition of port, ——.
State diseases prevailing at port and in surrounding country, ——.
Number of cases and the deaths from the following-named diseases during the past two weeks:

Diseases.	Number of Cases.	Number of Deaths.	Remarks. (Any condition affecting the public health existing in the port to be stated here. When there are no cases or deaths, entry to that effect must be made.)
Yellow fever....	....	....	
Asiatic cholera, cholera nostras, or cholerine.....	....	....	
Small-pox........	....	....	
Typhus fever....	....	....	
Plague.........	....	....	
Leprosy........	....	....	

Number and sanitary condition of passengers and crew landed at this port:
First cabin, No. ——; sanitary history and condition, ——.
Second cabin, No. ——; sanitary history and condition, ——.
Steerage, No. ——; sanitary history and condition, ——.
Crew, No. ——; sanitary condition and history, ——.

NOTE.—If any passenger or member of crew disembarked on account of sickness, state disease.

Number and sanitary condition of passengers and crew taken on at this port, and sanitary condition of effects:
First cabin, No. ——; sanitary condition and history, ——.
Second cabin, No. ——; sanitary condition and history, ——.
Steerage, No. ——; sanitary condition and history, ——.
Number of passengers for United States: —— first cabin, —— second cabin, —— steerage.

Crew, No. ———; sanitary condition and history, ———.
Sanitary condition of effects, ———.
Total passengers on board, ———; total crew on board, ———.
Sanitary measures, if any, adopted while in port, ———.
Location of vessel while in port—wharf, ———; open bay, ———; distance from shore, ———.
Time vessel was in port, ———.
Character of communication with shore, ———.
Nature, sanitary history, and condition of cargo taken on at this port, ———.

(Cancel Form A, B, or C, as the case requires.)

Form.

A.—To the best of my knowledge and belief—

(Form A will be used at intermediate ports where the vessel does not enter and clear.)

B.—I have satisfied myself that—

(Form B will be used at intermediate ports where the vessel enters and clears.)

} no quarantinable disease has appeared aboard since leaving ———.

C.—Since leaving ——— the following quarantinable disease has appeared on board ———, and I certify that the necessary sanitary measures have been taken.

I certify also that with reference to the passengers, effects, and cargo taken on at this port, the vessel has complied with the rules and regulations made under the act of February 15, 1893.

Given under my hand and seal this ——— day of ———, 191—.

(Signature of consular officer:) ——— ———,
——— ———.

4. Under the act of Congress approved August 18, 1894, vessels plying between Canadian ports on the St. Croix River, the St. Lawrence River, the Niagara River, the Detroit River, the St. Clair River, and the St. Mary's River, and adjacent ports of the United States on the same waters; also vessels plying between Canadian ports on the following-named lakes, viz., Ontario, Erie, St. Clair, Huron, Superior, Rainy Lake, Lake of the Woods, and Lake Champlain, and ports in the United States; also vessels plying between Mexican ports on the Rio Grande River and adjacent ports in the United States, are exempt from the provisions of section 2 of the act granting additional quarantine powers and imposing additional duties upon the Marine-Hospital Service, approved February 15, 1893, which requires vessels clearing from a foreign port for a port in the United States to obtain from the consular or medical officer a bill of health. During the prevalence of any of the quarantinable diseases at the foreign port of departure, vessels above referred to are hereby required to obtain from the consular officer of the United States, or from the medical officer of the United States, when such officer has been detailed by the President for this purpose, a bill of health, or a supplemental bill of health, in duplicate, in the form prescribed by the Secretary of the Treasury.

FOREIGN AND INSULAR REGULATIONS.

INSPECTION OF VESSELS LEAVING FOREIGN PORTS AND PORTS IN THE POSSESSIONS OR OTHER DEPENDENCIES OF THE UNITED STATES FOR PORTS IN THE UNITED STATES OR ITS POSSESSIONS OR OTHER DEPENDENCIES.

5. The officer issuing the bill of health shall satisfy himself, by inspection, if necessary, that the conditions certified to therein are true, and is authorized, in accordance with the law, to withhold the bill of health or the supplemental bill of health until he is satisfied that the vessel, the passengers, the crew, and the cargo have complied with all the quarantine laws and regulations of the United States.

6. Inspection is required of—

(*a*) All vessels from ports at which cholera, yellow fever, or plague prevails, or at which small-pox or typhus fever prevails in epidemic form.

(*b*) All vessels carrying steerage passengers; but need only include the inspection of such passengers and their living apartments, if sailing from a healthy port.

7. Inspection of the vessel is such an examination of the vessel, cargo, passengers, crew, personal effects of same, including examination of manifests and other papers, food and water supply, the ascertainment of its relations with the shore, the manner of loading and possibilities of invasion by small animals as will enable the inspecting officer to determine if these regulations have been complied with.

8. When an inspection is required, it should be made by daylight, as late as practicable before sailing. The vessel should be inspected before the passengers go aboard, the passengers just before embarkation, and the crew on deck; and no communication should be had with the vessel after such inspection except by permission of the officer issuing the bill of health.

GENERAL REQUIREMENTS (FOREIGN AND INSULAR)

9. Vessels, prior to storing cargo or receiving passengers, should be mechanically clean in all parts, especially the hold, forecastle, and steerage.

10. Any portions of the vessel liable to have been infected by any communicable disease should be disinfected before the issuance of the bill of health.

11. The air space, ventilation, food and water supply, hospital accommodations, and all other matters mentioned therein promotive of the health and comfort of the passengers must be in accordance with the provisions of the act of Congress approved

August 2, 1882, entitled "An act to regulate the carriage of passengers by sea."

12. Street sweepings, city cleanings, or anything containing organic refuse should not be taken as ballast from any port.

13. Bedding, upholstered furniture, soiled wearing apparel, personal effects, and secondhand articles of a similar nature, coming from a district known to be infected with cholera, small-pox, typhus fever, or as to the origin of which no positive evidence can be obtained, and which the consular or medical officer has reason to believe are infected, should be disinfected prior to shipment. In the case of typhus fever, the destruction of vermin should be assured. Articles similar to the above mentioned, if from a district infected by plague, should be inspected, and, if necessary, disinfected and treated to destroy vermin.

14. Articles from an uninfected district shipped through an infected port may be accepted without restriction if not exposed to infection in transit.

15. Nothing in these regulations shall be construed to modify or affect in any way any existing restrictions promulgated by the Secretary of the Treasury at the instance of the Secretary of Agriculture, regarding the importation of hides of neat cattle.

16. Any article shipped from or through an infected port or place, and which the consul or medical officer has reason to believe infected, should be disinfected.

17. Any article presumably infected, which cannot be disinfected, should not be shipped.

18. Passengers, for the purposes of these regulations, are divided into two classes, cabin and steerage.[1]

19. So far as possible passengers should avoid embarking at a port where quarantinable disease prevails, and communication between the vessel and the shore should be reduced to a minimum. In such a port the personnel of the vessel should remain on board during their stay.

Vessels carrying passengers from any port where quarantinable disease prevails in epidemic form should have a medical officer.

20. No person suffering from a quarantinable disease, or scarlet fever, measles, diphtheria, or other communicable disease, should be allowed to ship.

21. All baggage of steerage passengers destined for the United States should be labeled. If the baggage is in good sanitary condition, the label shall be a red label bearing the name of the

[1] The sanitary measures applicable to second-cabin pasengers will be those designated for first-cabin pasengers or for steerage passengers, according as the arrangements of their quarters and accommodations aboard, both sanitary and for association, class them in the opinion of the inspecting officer with the first cabin or steerage.

port, the steamship on which the baggage is to be carried, the word "passed" in large type, the date of inspection, and the seal or stamp of the consular or medical officer of the United States. All baggage that has been disinfected shall bear a yellow label, upon which shall be printed the name of the port, the steamship upon which the baggage is to be carried, the word "disinfected" in large type, the date of disinfection, and the seal or stamp of the consular or medical officer of the United States. It is understood, and it will be so printed on the blank, that the label is not valid unless bearing the consular or medical officer's stamp or seal.

22. Each steerage passenger shall be furnished with an inspection card. (See p. 490.) This card, stamped by the consular or medical officer, is to be issued to every member of a family as well as to the head thereof.

23. Passengers and crews, merchandise, and baggage, prior to shipment at a non-infected port, but coming from an infected locality, should be subject to the same restrictions as are imposed at an infected port.

SPECIAL REGULATIONS ON ACCOUNT OF CHOLERA, FOREIGN AND INSULAR.

24. At ports where cholera prevails, special care should be taken to prevent the water and the food supply from being infected. The drinking water, unless of known purity, should be boiled, and the food thoroughly cooked and protected against contamination by flies, etc.

25. The latrines of vessels must be so arranged that they, including their discharge pipes, can be made and kept mechanically clean.

26. Unless unavoidable, vessels should not take water ballast from a source contaminated or suspected of contamination by cholera. When unavoidable, the facts will be noted on the bill of health. (See paragraphs 75 and 101.)

27. Certain food products, viz., unsalted meats, sausages, dressed poultry, fresh butter, fresh milk (unsterilized), fresh cheese, coming from cholera-infected localities or through such localities, if exposed to infection therein, should not be shipped. Fresh fruits and vegetables, from districts where cholera prevails, shall be shipped only under such sanitary supervision as will enable the inspector to certify that they have not been exposed to infection.

28. All rags and textile fabrics used in the manufacture of paper and for other purposes which are collected, packed, or handled in any foreign port or place, with the exceptions as hereinafter specified, shall, prior to shipment to the United States, be subjected

INSPECTION CARD.

[Immigrants and steerage passengers.]

Port of departure.................................... *Date of departure*....................

Name of ship..

Name of immigrant.................... *Last permanent residence*....................

Inspected and passed at	Passed at quarantine, port of	Passed by Immigration
....	...................., United States.	Bureau, port of..................
[Seal or stamp of consular or medical officer.]	.... [Date.]	.... [Date.]

[The following to be filled in by ship's surgeon or agent prior to or after embarkation.]

Ship's list or manifest.......................... *No. on ship's list or manifest*............

Berth No.	Steam-ship inspec-tion.	1st day.	2	3	4	5	6	7	8	9	10	11	12	13	14	To be punched by ship's surgeon at daily inspec-tion.
....																

VACCINATED.

[Signature or Stamp.]

[Reverse Side.]

Keep this Card to avoid detention at Quarantine and on Railroads in the United States.

Diese Karte muss aufbewahrt werden, um Aufenthalt an der Quarantäne, sowie auf den Eisenbahnen der Vereinigten Staaten zu vermeiden.

Cette carte doit être conservée pour éviter une détention à la Quarantaine, ainsi que sur les chemins de fer des États-Unis.

Deze kaart moet bewaard worden, ten einde oponthoud aan de Quarantijn, alsook op de ijzeren wegen der Vereenigde Staten te vermijden.

Conservate questo biglietto onde evitare detenzione alla Quarantina e sulle Ferrovie degli Stati Uniti.

Tento lístek musíte uschovati, nechcete-li ukarantény (zastavení ohledně zjištěni zdraví) neb na dráze ve spojenych státech zdržení býti.

Tuto kartočku treba trímat' u sebe aby sa predešlo zderžovaňu v karantene aj na železnici ve Spojenych Státoch.

to disinfection by one of the prescribed methods. (Jute bags or bagging used in baling cotton, old rope, new cotton, or linen cuttings from factories not included.) The disinfection of the articles mentioned above shall be performed under the supervision of a United States consul or a medical officer of the United States, and a certificate in duplicate, signed by said consul or medical officer, shall be issued with each consignment of same, which certificate shall identify the articles and state that they have been disinfected in accordance with the United States quarantine regulations. The original certificate of disinfection shall be attached to the consignee's invoice, and where the articles are carried by sea the duplicate certificate of disinfection shall be attached to the bill of health issued to the vessel conveying the same.

Exceptions.—Such articles shipped from the Dominion of Canada directly to the United States shall be exempt from this requirement if accompanied by affidavits demonstrating to the satisfaction of the collector of customs at the port of arrival that they have actually originated in Canada and have not been shipped from a foreign country to Canada, and thence shipped to the United States; and further, that the port or place where collected or handled has been free from quarantinable disease for thirty days prior to shipment.

29. Steerage passengers and crew coming from cholera-infected districts should be detained five days in suitable houses or barracks located where there is no danger from infection, and all baggage disinfected.

30. Steerage passengers and crew from districts not infected with cholera, shipping at a port infected with cholera, unless passed through without danger of infection and no communication allowed between such persons and the infected locality, should be treated as those in the last paragraph.

31. Cabin passengers coming from cholera-infected districts embarking at a clean or an infected port should produce satisfactory evidence as to their exact places of abode during the five days immediately preceding embarkation. And if it appears that they or their baggage have been exposed to infection, the baggage should be disinfected and the passengers detained under medical supervision a sufficient time to cover the period of incubation since last exposure.

32. Should cholera appear in the barracks or houses in which passengers are undergoing detention, no passenger from said houses or barracks who has been presumably exposed to this new infection should embark until after the expiration of the period of incubation of the disease in question subsequent to the last exposure to infection and the application of all necessary sanitary measures.

SPECIAL REGULATIONS ON ACCOUNT OF YELLOW FEVER, FOREIGN AND INSULAR.

33. It is advisable that at ports where yellow fever prevails, precautions should be taken to prevent the introduction of mosquitoes (stegomyia) on board the vessel. Water tanks, water buckets, and other collections of water about the vessel should be guarded in such a manner that they shall not become breeding places for mosquitoes. Where the vessel has lain in such proximity to the shore at such places as to render it liable, in the opinion of the inspecting officer, to the access of mosquitoes, measures should be taken to destroy mosquitoes that may have come on board.

34. Passengers and crew who, in the opinion of the inspecting officer, have been definitely exposed to the infection of yellow fever (*i. e.*, as from a house or locality known to be infected), should not be allowed to embark for six days after said exposure. Those immune to yellow fever are exempt from this provision.

SPECIAL REGULATIONS ON ACCOUNT OF PLAGUE, FOREIGN AND INSULAR.

35. At ports or places where plague prevails in men or rodents every precaution should be taken to prevent rats, fleas, or other vermin from getting aboard. At such ports or places the vessel should not lie at a dock or tie to the shore or anchor at any place where rats may gain access to the vessels. Lighters should not harbor rats, and the introduction of rats from them should be very carefully guarded against.

36. In case lines are led to the shore they should be freshly tarred and provided with inverted cones or such other devices as may prevent rats passing to the ship.

37. If the vessel docks the lines should be treated as directed in the last paragraph, and all parts of the vessel fumigated, simultaneously, if possible, for the purpose of killing rats and other vermin, before sailing.

38. Vessels arriving at a foreign port in transit, having previously lain in a plague-infected port without taking proper precautions to prevent the ingress of rats and fleas, should be fumigated to kill such vermin, provided effective fumigation for killing such vermin has not already been done, and that this fumigation can be done efficiently.

39. Articles which harbor or are liable to harbor rats or rat fleas, should not be shipped until freed of such vermin, either by the use of chemicals, fumigation, or solutions, or by preventing the access of rats for fifteen days before shipment. The nature of the merchandise and the place and method of stowing

prior to shipment must be considered in determining its liability to be a rat or vermin carrier, thus: Bundles of hides, bags of grain, etc., so stowed as to be used as nesting places for rats would be flea, and might be rat, carriers.

When the cargo of a vessel consists of grain or other rat food, extra precautions should be taken to prevent rats from going aboard.

Hides chemically cured are not liable to harbor rats or rat fleas; and loose, single hides are less liable to do so than when baled.

40. Passengers and crew who, in the opinion of the inspecting officer, have been definitely exposed to the infection of plague (*i. e.*, as from a house or locality known to be infected) should not be allowed to embark for seven days after said exposure, unless already immune to plague by recent previous attack, or prophylactic serum. All baggage from such ports shall be subject to inspection, and if necessary disinfected and treated to destroy vermin.

SPECIAL REGULATIONS ON ACCOUNT OF SMALL-POX, FOREIGN AND INSULAR.

41. Steerage passengers and crew coming from districts where small-pox prevails in epidemic form, or who have been exposed to small-pox, should be vaccinated before embarkation, unless they show satisfactory evidence of having acquired immunity to small-pox by previous attack, or successful vaccination within one year, and their baggage inspected and if necessary disinfected.

SPECIAL REGULATIONS ON ACCOUNT OF TYPHUS FEVER, FOREIGN AND INSULAR.

42. Steerage passengers and crew who, in the opinion of the inspection officer, have been exposed to the infection of typhus fever, should not be allowed to embark for a period of at least twelve days after such exposure and until their baggage has been disinfected and the destruction of vermin assured.

SPECIAL REGULATIONS ON ACCOUNT OF LEPROSY, FOREIGN AND INSULAR.

43. No alien who is a leper should be allowed to embark for the United States.

RECORDS, REPORTS, ETC., FOREIGN AND INSULAR.

44. The officer making the inspection will preserve in his office a record of each inspection made and of each immu

certificate given; a copy of each certificate of disinfection and of each bill of health issued.

A weekly report of the transactions of his office shall be forwarded to the Surgeon-General at Washington, D. C.

45. In addition to the duties prescribed, the medical officer when detailed in accordance with the act of Congress approved February 15, 1893, shall furnish such reports to the Surgeon-General of the Public Health and Marine-Hospital Service as he may be able to make upon sanitary conditions and other matters affecting the public health and the welfare of the Service administration.

REQUIREMENTS AT SEA.[1]

46. The master of a vessel should observe the following measures on board his vessel:

(*a*) The water-closets, forecastle, bilges, and similar portions of the vessel liable to harbor infection should be disinfected and frequently cleansed.

(*b*) Free ventilation and rigorous cleanliness should be maintained in all portions of the ship during the voyage and measures taken to destroy rats, mice, fleas, flies, roaches, mosquitoes, and other vermin.

(*c*) A patient sick of a communicable disease should be isolated and one member of the crew detailed for his care and comfort, who, if practicable, should be immune to the disease.

(*d*) Communication between the patient or his nurse and other persons on board should be reduced to a minimum.

(*e*) Used clothing, body linen, and bedding of the patient and nurse should be immersed at once in boiling water or in a disinfecting solution.

(*f*) The compartment from which the patient was removed should be disinfected and thoroughly cleansed. Articles liable to convey infection should remain in the compartments during the disinfection when gaseous disinfection is used.

(*g*) Any person suffering from malaria or yellow fever should be kept under mosquito bars and the apartment in which he is confined closely screened with mosquito netting. All mosquitoes on board should be destroyed by burning pyrethrum powder (Persian insect powder) or by fumigation with sulphur. Mosquito larvæ (wigglers or wiggle-tails) should be destroyed in water-barrels, casks, and other collections of water about the vessel by the use of petroleum (kerosene); where this is not practicable, use mosquito netting to prevent the exit of mosquitoes from such breeding places.

[1] These requirements at sea are largely advisory in character, but it is nevertheless true that a careful compliance with them should tend, at the port of arrival, to largely relieve the stringency of quarantine measures.

(*h*) In the case of plague, special measures must be taken to destroy rats, mice, fleas, ants, and other vermin on board.

(*i*) In the case of typhus[1] special measures should be taken in addition to disinfection to destroy vermin.

(*j*) In the case of cholera, typhoid fever, or dysentery, the drinking water should be boiled and the food thoroughly cooked. The discharges from the patient should be immediately disinfected and thrown overboard.

47. An inspection of the vessel, including the steerage, should be made by the ship's physician once each day.

48. Should cholera, yellow fever, small-pox, typhus fever, plague, or any other communicable disease appear on board a ship while at sea, those who show symptoms of these diseases should be immediately isolated in a proper place; the ship's physician should then immediately notify the captain, who should note same in his log, and all of the effects liable to convey infection which have been exposed to infection should be destroyed or disinfected.

49. The hospital should be disinfected as soon as it becomes vacant.

50. The dead should be enveloped in a sheet saturated with one of the strong disinfecting solutions, without previous washing of the body, and at once buried at sea or placed in a coffin hermetically sealed.

51. A complete clinical record should be kept by the ship's surgeon of all cases of sickness on board, and the record delivered to the quarantine officer at the port of arrival.

52. The following disinfecting solutions are recommended for use at sea:

Formulas for Strong Disinfecting Solutions.

Bichlorid of Mercury (1 : 500).

Bichlorid of mercury	1 part
Sea-water	500 parts.
Mix.	

Carbolic Acid (5 per cent.).

Alcohol	50 parts
Carbolic acid, pure	50 parts
Mix.	
Then add fresh water	900 parts.

Formulas for Weak Solutions.

Bichlorid of Mercury (1 : 1000).

Bichlorid of mercury	1 part
Sea-water	1000 parts.

[1] It is now accepted that typhus fever may be transmitted through the agency of lice.

Carbolic Acid (2½ per cent.).

Carbolic acid, pure	25 parts
Fresh water	1000 parts.

Formalin (5 per cent.).

Formalin (or formol)	25 parts
Water	950 parts.

It is suggested that a vessel should carry for every 100 passengers: Bichlorid of mercury, 5 pounds; carbolic acid, 10 pounds; alcohol, 10 pounds, and formalin, 10 pounds.

DOMESTIC REGULATIONS.

Quarantine Regulations to be Observed at Ports and on the Frontiers of the United States and its Possessions and Dependencies.

PREAMBLE.

53. At or convenient to the principal ports, quarantine stations should be equipped with all appliances for the inspection and treatment of vessels, their passengers, crews, and cargoes.

54. For all ports where such provisions have not been made, inspection stations should be maintained. An inspection service should be maintained for every port throughout the year.

55. At a fully equipped quarantine station there should be adequate provision for boarding and inspection, apparatus for mechanical cleansing of vessels, apparatus for disinfection by steam, by sulphur, by formaldehyd, by disinfecting solutions, or any other methods prescribed in these regulations; also a clinical laboratory, hospitals for contagious and doubtful cases, a steam laundry, detention barracks for suspects, bathing facilities, a crematory, a sufficient supply of good water, and a proper system for the disposal of sewage.

56. The personnel of quarantine stations in the yellow-fever zone and on fruiters and other vessels of regular lines bound for southern ports from ports where yellow fever prevails should be immune to yellow fever.

57. At quarantine stations all articles liable to convey infection should be handled only by the employees of said station unless the services of the crew of the vessel in quarantine are indispensable.

58. Vessels having been treated at national quarantine stations that are located a considerable distance from the ports of entry of said vessels may be inspected by the local quarantine officer, and if for any sanitary reason it is considered inadvisable to admit the vessel, he should report the facts immediately by telegraph, when possible, to the Surgeon-General of the Public Health and Marine-Hospital Service, detaining the vessel pending his action.

59. The following regulations are the required minimum standard and do not prevent the addition of such other rules as, for special reasons, may be legally made by State or local authorities.

INSPECTION.

60. Every vessel subject to quarantine inspection, entering a port of the United States, its possessions or dependencies, shall be considered in quarantine until given free pratique. Such vessel shall fly a yellow flag at the foremost head from sunrise to sunset, and shall observe all the other requirements of vessels actually quarantined.

61. Vessels arriving at ports of the United States under the following conditions shall be inspected by a quarantine officer prior to entry:

(*a*) All vessels from foreign ports except those enumerated in paragraph 4.

(*b*) Any vessel with sickness on board.

(*c*) Vessels from domestic ports where cholera, plague, or yellow fever prevails, or where small-pox or typhus fever prevails in epidemic form.

(*d*) Vessels from ports suspected of infection with yellow fever, having entered a port north of the southern boundary of Maryland without disinfection, shall be subjected to a second inspection before entering any ports south of said latitude during the quarantine season of such port.

62. The inspections of vessels required by these regulations shall be made between sunrise and sunset, except in case of vessels in distress. Exception may also be made in the case of fruit vessels carrying perishable cargoes, and regular line vessels carrying passengers, under regulations approved by the Secretary of the Treasury.

63. In making the inspection of a vessel, the bill of health and clinical record of all cases treated during the voyage, crew and passengers' lists and manifests, and when necessary, the ship's log shall be examined. The crew and passengers shall be mustered and examined and compared with the lists and manifests and any discrepancies investigated. The clinical thermometer should be used in the examination of the personnel of vessels under suspicion. When a freight manifest shows that rags and other articles requiring disinfection under these regulations are carried by the vessel, a certificate of disinfection, signed by a United States consul or a medical officer of the United States, shall be exhibited and compared with same. If no certificate of disinfection is produced, the collector of customs at the port of entry shall be notified of same by the quarantine officer. The collector of customs shall then hold such consignment in a designated place

separate from other freight pending the arrival of the certificate of disinfection; and in the event of its non-arrival, the articles shall be disinfected as hereinbefore prescribed, or shall be returned by the common carrier conveying same.

64. The medical officers of the United States, duly clothed with authority to act as quarantine officers at any port or place within the United States, and when performing the said duties, are hereby authorized to take declarations and administer oaths in matters pertaining to the administration of the quarantine laws and regulations of the United States. (Act of March 2, 1901, sec. 12.)

65. No person, except the quarantine officer, his employees, United States customs officers, pilots, or other persons authorized by the quarantine officer, shall be permitted to board any vessel subject to quarantine inspection until after the vessel has been inspected by the quarantine officer and granted free pratique, and all such persons so boarding such vessel shall, in the discretion of the quarantine officer, be subject to the same restrictions as the personnel of the vessel.

66. Towboats or any other vessels having had communication with vessels subject to inspection shall themselves be subject to inspection.

67. After arrival at a quarantine station of a vessel carrying immigrants and upon which there has appeared during the last voyage a case of cholera, small-pox, typhus fever, or plague, and after quarantine measures provided by regulations of the Treasury Department have been enforced and the vessel given free pratique it is hereby ordered that notification of the above-mentioned facts be transmitted by the quarantine officer to the Commissioner of Immigration at the port of arrival, who shall be requested to transmit, by mail or telegraph, to the State health authorities of the several States to which immigrants from said vessel are destined, the date of departure, route, number of immigrants, and the point of destination in the respective States of the immigrants from said vessel, together with the statement that said immigrants are from a vessel which has been subject to quarantine by reason of infectious disease, naming the disease. This information is furnished to State health officers for the purpose of enabling them to maintain such surveillance over the arriving immigrants as they may deem necessary.

68. When a vessel arriving at quarantine has on board any of the communicable but unquarantinable diseases, the quarantine officer shall promptly inform the local health authorities of the existence of such disease aboard and shall make every effort to furnish such notification in ample time, if possible, to permit of the case being seen by the local authorities before discharge from the vessel.

QUARANTINE.

69. Vessels arriving under the following conditions shall be placed in quarantine:

(*a*) With quarantinable disease on board or having had such disease on board during the voyage.

(*b*) Any vessel which the quarantine officer considers infected.

(*c*) A vessel arriving at a port south of the southern boundary of Virginia in the season of close quarantine. April 1 to November 1, from a tropical American port, unless said port is known to be free from yellow fever.

(*d*) Vessels arriving at ports north of this line, and south of the southern boundary of Maryland, between May 15 and October 1, if from a tropical port, unless said port is known to be free from yellow fever.

(*e*) Vessels arriving at a southern port, referred to in paragraphs (*c*) and (*d*) during the season of close quarantine for such ports, via a northern port, when from a port known to be infected with yellow fever, unless six days have elapsed since the fumigation of the vessel in such northern port and certificate be presented from the quarantine officer at such northern port, or an accredited medical officer of the United States.

(*f*) In the case of vessels arriving at a northern port without sickness on board from ports where yellow fever prevails, the personnel shall be detained under observation at quarantine to complete five days from the port of departure.

(*g*) Towboats and other vessels having had communication with vessels subject to quarantine shall themselves be quarantined if they have been exposed to infection.

70. Vessels engaged in the fruit trade may be admitted to entry without detention, provided that they have complied in all respects with the special rules and regulations made by the Secretary of the Treasury with regard to vessels engaged in said trade.

GENERAL REQUIREMENTS AT QUARANTINE.

71. Pilots will be detained in quarantine a sufficient time to cover the period of incubation of the disease for which the vessel is quarantined, if, in the opinion of the quarantine officer, such pilots have been exposed to infection. The dunnage of pilots shall be disinfected when necessary.

72. No direct communication shall be allowed between any vessel in quarantine and any person or place outside, and no communication whatever between quarantine or any vessel in quarantine and any person or place outside except under the supervision of the quarantine officer.

73. Street cleanings, street sweepings, or any other form of ballast containing organic refuse must be discharged at the quarantine station.

74. No presumably infected ballast shall be allowed to leave the quarantine station until disinfected.

75. After a vessel has been rendered free from infection, it may be furnished with a fresh crew and released from quarantine, while all or part of the personnel is detained. Under these circumstances the quarantine officer must exercise the greatest care that the vessel shall not become reinfected, especially by contact with persons in quarantine or infected objects.

76. Vessels detained at any national quarantine will be subject to such additional rules and regulations as may be promulgated from time to time by the Surgeon-general.

77. The form of certificate which shall be issued to a vessel by the health officer when he releases her from quarantine shall be prescribed by the Surgeon-General of the Public Health and Marine-Hospital Service, and shall embody the statement that the vessel has in all respects complied with the quarantine regulations prescribed by the Secretary of the Treasury, and that in the opinion of the quarantine officer she will not convey quarantinable disease, and that said vessel is granted free pratique to enter her port of destination, the name of which is to be embodied in the blank.

78. The persons detained shall be inspected by the physician twice daily, and be under his constant surveillance, and no intercourse will be allowed between different groups while in quarantine.

79. No articles from an infected vessel shall be carried into the place of detention until disinfected.

80. Cleanliness of quarters and of person shall be enjoined and daily enforced. Disinfection shall be practised where there is any possibility of infection.

81. Water-closets, urinals, privies, or troughs shall be provided.

82. In any group in which communicable disease appears, the sick will be immediately isolated in hospital, and the remaining persons in the group and their effects appropriately treated and then removed to other quarters, if possible, and the compartments disinfected.

83. Communication between the physician and attendants of the hospital and those detained in other parts of the quarantine station shall be reduced to a minimum.

84. No convalescent shall be discharged from quarantine until after a sufficient time has elapsed to insure his freedom from infection, and this is to be determined by bacteriologic examination where possible.

85. No other person shall be discharged from quarantine until the period of incubation of the disease has elapsed since the last exposure to infection.

86. The body of no person dead of quarantinable disease shall be allowed to pass through quarantine until one year has elapsed since death. Such bodies must be transported in hermetically sealed coffins, the outsides of which have been carefully disinfected.

In the case of the bodies of such persons as may have died on the voyage or upon arrival at quarantine, cremation should be resorted to if practicable and consented to; if not, the body should be wrapped without preliminary washing in a sheet saturated with a solution of bichlorid of mercury 1:500 and buried, surrounded by caustic lime.

87. The quarantine officer shall report to the Secretary of the Treasury all violations of the quarantine laws. He should also report the facts in the case to the Surgeon-General of the Public Health and Marine-Hospital Service.

88. The quarantine officer shall report to the collector of customs any vessel which arrives without the bill of health hereinbefore prescribed.

89. All vessels requiring inspection under these regulations must present to the collector of customs at the port of entry the quarantine certificate above prescribed.

SPECIAL REGULATIONS ON ACCOUNT OF CHOLERA.

90. For the purpose of these regulations five days shall be considered as the period of incubation of cholera.

91. If the vessel carry persons from cholera-infected ports or places, a bacteriologic examination should be made of any cases of diarrhea to exclude cholera before granting free pratique.

92. If cholera has appeared on board, remove all passengers from the vessel and all of the crew, save those necessary to care for her; place the sick in hospital. Carefully isolate those especially suspected, and segregate the remainder in small groups. No communication should be held between these groups. Those believed to be especially capable of conveying infection must not enter the place of detention until they are bathed and furnished with non-infected clothing; nor shall any material capable of conveying infection be taken into the place of detention, especially food and water.

93. Water and food supply must be strictly guarded to prevent contamination, and issued to each group separately.

94. Food of a simple character, sufficient in quantity, thoroughly cooked, shall be issued to those detained in quarantine. No fruit or uncooked vegetables shall be permitted.

95. The greatest care must be exercised to prevent the spread of the infection through the agency of flies or other insects.

96. The dejecta from all persons in quarantine on account of cholera shall be disinfected before final disposition.

97. The water supply of the vessel, if suspected of infection, must be disinfected and then changed without delay; the casks or tanks disinfected, and after thorough rinsing refilled from a source of undoubted purity, or the water furnished must have been recently boiled.

98. The baggage or effects of passengers and crew that may have been exposed to infection must be disinfected.

99. Articles of cargo which have been exposed to infection and are liable to convey the same must be disinfected.

100. Living apartments and their contents and such other portions of the vessel as have been exposed to infection must be disinfected.

101. Water ballast taken on at a cholera-infected port should be discharged at sea, or if discharged in fresh or brackish water, must previously be disinfected. Vessels arriving with water ballast presumably infected must return to sea under guard in order to discharge such ballast. If practicable, the tanks should be disinfected before being flushed, and refilled with sea-water. (See also paragraphs 26 and 75.)

SPECIAL REGULATIONS ON ACCOUNT OF YELLOW FEVER.

102. For the purpose of these regulations, six days shall be considered as the period of incubation of yellow fever.

103. A vessel aboard which a case of yellow fever has occurred at any time during the voyage shall be treated as follows:

(*a*) Careful visual and thermometer inspection of all persons.

(*b*) The sick are to be immediately disembarked, protected by netting against the access of stegomyia mosquitoes, and transferred to a place of isolation.

(*c*) Other persons should be disembarked, if possible, and subjected to an observation of six days, dating from the day of last possible exposure.

(*d*) Persons under observation presenting an elevation ot temperature above 37.6° C. shall be isolated in a screened apartment.

(*e*) The ship shall be moored at least 200 meters from the inhabited shore.[1]

(*f*) The ship shall be fumigated for the destruction of mosquitoes before the discharge of cargo, if possible. If a fumigation be not possible before the discharge of the cargo, the dis-

[1] No national quarantine station is within 200 meters of an inhabited shore.

charge of cargo shall be under the supervision of the quarantine officer, and may be permitted as follows: By (1) the employment of immune persons for discharging the cargo; or (2) if non-immunes be employed, they shall be kept under observation during the discharging of cargo and for six days, to date from the last day of exposure on board.

104. A vessel which has lain in such proximity to the shore of a port infected or suspected as to render it liable to the access of stegomyia mosquitoes is to be subjected to the measures which are indicated in (*a*), (*c*), and (*f*) of the preceding paragraph.

105. A vessel arriving at a southern port which, although coming from an infected or suspected port, has had neither death nor case of yellow fever on board, either before departure, during the voyage, or at the time of arrival, and which the quarantine officer is satisfied has not lain in such proximity to the shore as to render it liable to the access of stegomyia mosquitoes, or which has been fumigated under the supervision of an accredited medical officer of the United States immediately before sailing, may, upon arrival at a port of destination in the United States with good sanitary history and in good condition, be subjected to the following treatment:

(*a*) If arriving in six days or less, she may be admitted to pratique, with or without fumigation, in the discretion of the quarantine officer, and without further detention than is necessary to complete six days.

(*b*) If arriving after six days and within twelve days, she may be immediately fumigated and admitted without detention.

(*c*) If arriving after a longer voyage than twelve days, she shall be treated as required by paragraph 103 (*a*), (*c*), and (*f*).[1] If the vessel should have been in transit for a considerable number of days it is obvious that a case of yellow fever may have occurred and recovered, leaving the vessel infected and not affording any opportunity to the quarantine officer to determine same.

106. Traffic without detention may be allowed during the close quarantine season, from ports infected or suspected of infection with yellow fever to ports in the United States south of

[1] A vessel in this class is one aboard which there are no infected stegomyiæ and no persons infective to stegomyiæ—that is, sick of yellow fever.

It may have aboard uninfected stegomyiæ, which bred aboard or were carried aboard from some previous port, and persons in the incubative period of yellow fever.

If a case of yellow fever develops and infects the stegomyiæ aboard, the stegomyiæ must be destroyed before granting pratique, but as such stegomyiæ have not been found capable of conveying yellow fever until twelve days have elapsed after biting one sick of yellow fever, the personnel of the vessel is not exposed to infection up to this time and can be landed with safety prior to this time. Twelve days is the minimum time observed, one case only, for the incubation in the mosquito—the extrinsic incubation of yellow fever.

the southern boundary of Maryland under the following conditions:

(*a*) The vessel must lie at approved moorings in the open harbor; the crew must not be allowed ashore at the port of departure. Every possible precaution must be taken to prevent the ingress of stegomyia mosquitoes and their access to the crew.

(*b*) All passengers and the officer who must go ashore to enter his vessel must be immune to yellow fever, or must have been free from possible exposure to yellow fever for six days immediately prior to embarking.

(*c*) All the above conditions to be certified to specifically by an accredited medical officer of the United States.

107. All persons who can prove their immunity to yellow fever, to the satisfaction of the health authorities, or who have not been exposed to possible infection of yellow fever, may be permitted to land at once.[1]

108. For the destruction of mosquitoes there shall be a complete and simultaneous fumigation of all parts of the vessel by sulphur dioxid gas, 2 per cent. volume gas, two hours' exposure. Where sulphur is liable to injure articles, pyrethrum powder, camphophenol, or other approved culicide may be used instead. (See also paragraph 67.)

SPECIAL REGULATIONS ON ACCOUNT OF PLAGUE.

109. For the purpose of these regulations seven days shall be considered as the period of incubation of plague.

110. Ships aboard which plague has occurred in men or rats are to be subjected to the following treatment:

(*a*) Careful inspection.

(*b*) The sick, if any, are to be immediately disembarked and isolated.

(*c*) The destruction of rats on shipboard shall be effected as soon as practicable. Cargo must be partially or completely removed if necessary for effective destruction of rats. Proper precautions shall be taken to prevent rats getting ashore.

(*d*) All personnel to be held under observation not less than five days, which period may, in the judgment of the quarantine officer, be extended to seven days in special cases.

(*e*) Soiled linen, personal effects in use, the belongings of crew and passengers which, in the opinion of the quarantine officer are considered as infected, shall be disinfected and rendered free from vermin.

(*f*) In all cases the quarantine officer shall assure himself that

[1] The evidence of immunity which may be accepted by the sanitary inspector is: First, proof of previous attack of yellow fever; second, proof of continued residence in an endemic focus of yellow fever for ten years.

the vessel is free from rats and vermin before granting free pratique.

111. Vessels from ports infected with plague, in men or rats, which have docked or which have not taken precautions necessary to prevent the ingress of rats or vermin, and on which effective measures have not been taken to destroy same under the supervision of an accredited medical officer of the United States, shall, upon arrival, be treated as follows:

(*a*) Careful inspection.

(*b*) Fumigation for the destruction of rats.

112. Vessels engaged in trade from ports infected with plague shall have such measures taken as will free them from rats not less than once every six months. This is best done by fumigation when the vessel is empty.

113. Treatment of vessels without cargo for plague shall be the simultaneous fumigation with sulphur dioxid, not less than 2 per cent. gas, for six hours' exposure.

114. Treatment of vessels with cargo shall be the fumigation with sulphur dioxid 4 per cent. gas, six to twelve hours' exposure, according to the stowing.

115. Infected vessels may require partial or complete discharge of cargo and fractional fumigation for efficient deratization.

116. For the deratization of all vessels, except those which have had plague in men or rats during the voyage, the oxids of carbon, applied by special apparatus in the volume and with the exposure described in paragraph 185, may be used. (See also paragraph 67.)

SPECIAL REGULATIONS ON ACCOUNT OF SMALL-POX.

117. For the purpose of these regulations, fourteen days shall be considered as the period of incubation of small-pox.

118. On all vessels arriving with small-pox on board, or having had small-pox on board during the voyage, any of the personnel who have been exposed to the infection of the disease must be vaccinated or detained in quarantine not less than fourteen days, unless they show satisfactory evidence of recent successful vaccination or of having had small-pox.

119. Vessels arriving with small-pox on board which has been properly isolated and other sufficient precautions taken to prevent the spread of the disease need not be quarantined further than the removal of the sick, the disinfection of all compartments, baggage, and objects that have been exposed to the liability of infection, and such vaccination of the personnel as required in paragraph 118.

120. On vessels arriving with small-pox on board and where the proper isolation and other precautions have not been taken,

all those whom the quarantine officer believes to have been exposed to the infection will be detained unless they have had small-pox or unless they show satisfactory signs of having been properly vaccinated within one year.

121. Living compartments and their contents or any other parts of the vessel exposed to the infection must be disinfected.

122. The baggage and effects of passengers and crew that have been exposed to the infection must be disinfected. (See also paragraph 67.)

SPECIAL REGULATIONS ON ACCOUNT OF TYPHUS FEVER.

123. For the purpose of these regulations twelve days shall be considered as the period of incubation of typhus fever.

124. Vessels in otherwise good sanitary condition, but having typhus fever on board which has been properly isolated, need not be quarantined further than the removal of the sick, and disinfection of the compartments and their contents exposed to infection.

125. If the case has not been isolated, or the disease has spread on board from person to person, the vessel will be quarantined, the sick removed, and those who have been exposed to the infection detained under observation.

126. Vessels in bad sanitary condition, on which the disease has appeared, will be quarantined until thoroughly cleansed and disinfected throughout; the sick will be cared for at isolated hospitals, and those exposed to the infection detained under observation.

127. The baggage and effects of passengers and crew that have been exposed to the infection must be disinfected.

128. Living compartments and their contents, or any other parts of the vessel exposed to the infection must be disinfected, and the destruction of vermin assured. (See also paragraph 67.)

SPECIAL REGULATIONS ON ACCOUNT OF LEPROSY.

129. Vessels arriving at quarantine with leprosy on board shall not be granted pratique until the leper with his or her baggage has been removed from the vessel to the quarantine station.

130. No alien leper shall be landed.

131. If the leper is an alien passenger and the vessel is from a foreign port, action will be taken as provided by the immigration laws and regulations of the United States. And to this end the case shall be certified as a leper and reported to the nearest commissioner of immigration.

132. If the leper is an alien and a member of the crew and the vessel is from a foreign port, said leper shall be detained at the quarantine at the vessel's expense until taken aboard by the same vessel when outward bound. Such case of leprosy should be promptly reported to the collector of customs at the port of

arrival of the vessel, and the collector shall exact a bond from the vessel for the reshipment of the said alien leper upon the departure of the vessel.

CANADIAN AND MEXICAN FRONTIERS.

133. When practicable, alien immigrants arriving at Canadian or Mexican ports destined for the United States, shall be inspected at the Canadian or Mexican port of arrival by the United States consular or medical officer, and be subjected to the same sanitary restrictions as are called for by the rules and regulations governing United States ports.

134. Inspection cards will be issued by the consular or United States medical officer at the Canadian or Mexican port of arrival to all such alien immigrants, and labels affixed to their baggage, as is required at foreign ports in the case of those coming direct to any port of the United States.

135. If any person be found suffering from a quarantinable disease, or be presumably infected, he shall be denied entry or shall be kept under quarantine observation so long as danger of conveying the infection exists.

136. Any baggage or other effects believed to be infected shall be refused entry unless disinfected in accordance with these regulations.

137. Persons coming from localities where cholera is prevailing shall not be allowed entry until after five days have elapsed since last presumable exposure to infection, and their baggage disinfected.

138. During the quarantine season persons not positively identified as immune to yellow fever, coming from places where yellow fever prevails, will not be permitted to enter until they have been away from said localities five full days.

139. Persons coming from localities where small-pox is prevailing shall not be allowed entry without vaccination, unless they are protected by a previous attack of the disease or a recent successful vaccination. The baggage of persons from such localities shall be disinfected.

140. Persons coming from localities where typhus fever prevails in epidemic form shall not be allowed entry until twelve days have elapsed since their last possible exposure to infection and the disinfection of their baggage.

141. Persons coming from localities where plague is prevailing shall not be allowed entry until seven days have elapsed since their last possible exposure to infection and the disinfection of their baggage.

142. No common carrier which is infected, or suspected of being infected, shall be allowed to enter the United States until after such measures have been taken as will render it safe.

143. Articles of merchandise, personal effects, etc., which are presumably infected, shall not be allowed entry into the United States until after disinfection.

144. Rags gathered and baled in Canada, accompanied by affidavits that the ports or places where collected or handled were free from quarantinable disease for thirty days prior to shipment, may be admitted to entry; but rags from foreign ports shipped through Canada shall not be admitted to entry unless they are accompanied by a certificate of a United States consul or medical officer of the United States that they have been disinfected, or until after they have been unbaled and disinfected at the port of arrival.

145. Where not otherwise specifically stated, the rules and regulations for maritime quarantine shall be applied as stations on the Canadian and Mexican frontiers; and the methods of disinfections shall be those prescribed in these regulations.

SPECIAL REGULATIONS RELATING TO NAVAL VESSELS.

146. Vessels of the U. S. Navy may be granted the hereinafter stated exemptions from quarantine regulations, but are subject to quarantine inspection upon arrival at a port of the United States.

147. The certificates of the medical officers of the U. S. Navy as to the sanitary history and condition of the vessel and its personnel may be accepted for naval vessels by the quarantine officer boarding the vessel in lieu of an actual inspection.

148. Vessels of the U. S. Navy having entered the harbors of infected ports, but having held no communication which is liable to convey infection, may be exempted from the disinfection and detention imposed on merchant vessels from such ports.

INSPECTION OF STATE AND LOCAL QUARANTINES.

149. In the performance of the duties imposed upon him by the act of February 15, 1893, the Surgeon-General of the Public Health and Marine-Hospital Service shall, from time to time, personally or through a duly detailed officer of the Public Health and Marine-Hospital Service, inspect the maritime quarantines of the United States, State and local, as well as national, for the purpose of ascertaining whether the quarantine regulations prescribed by the Secretary of the Treasury have been or are being complied with. The Surgeon-general, or the officer detailed by him as inspector, shall, at his discretion, visit any incoming vessel or any vessel detained in quarantine, and all portions of the quarantine establishment, for the above-named purpose, and with a view to certifying, if need be, that the regulations have been or are being enforced.

150. The Surgeon-General of the Public Health and Marine-Hospital Service is authorized, when in his discretion such action is necessary in the interest of the Public Health, to remand, by direction of the Secretary of the Treasury, any vessel to the nearest national, State, or local quarantine station provided with proper facilities for handling infected vessels.

Disinfectants Authorized by these Regulations and the Proper Methods of Generating and Using Same.

PHYSICAL DISINFECTANTS.

151. Burning. Of unquestioned efficiency, but seldom required.

152. Boiling. Very efficient and of wide range of applicability. The articles must be wholly immersed for not less than thirty minutes in water actually boiling (100° C.). The addition of 1 per cent. of carbonate of soda renders the process applicable to polished steel, cutting instruments, or tools.

153. Steam.

(*a*) Flowing steam (not under pressure). Flowing steam (not under pressure) when applied under suitable conditions is an efficient disinfecting agent. The exposure must be continued thirty minutes after the temperature has reached 100° C.

(*b*) Steam under pressure without vacuum. Steam under pressure will sterilize, provided that the process is continued twenty minutes after the pressure reaches 15 pounds per square inch. The air must be expelled from the apparatus at the beginning of the process. If impracticable to obtain the designated pressure, a longer exposure will accomplish the same result.

(*c*) Steam under pressure with vacuum. Steam in a special apparatus with vacuum attachment is the best method of applying steam under pressure, the object of the vacuum apparatus being to expel the air and to promote the penetration of the steam. The process is to be continued for twenty minutes after the pressure reaches 10 pounds to the square inch.

GASEOUS DISINFECTANTS.

154. Sulphur dioxid. Sulphur dioxid is efficient, but requires the presence of moisture. It is only a surface disinfectant, and is lacking in penetrating properties. An atmosphere containing 4.5 per cent. can be obtained by burning 5 pounds of sulphur per 1000 cubic feet of space. This amount would require the evaporation or volatilization of about 1 pint of water. Under these conditions the time of exposure should be not less than twenty-four hours for bacterial infections. A shorter time will suffice for fumigation necessary to kill mosquitoes and other vermin.

155. The sulphur may be burned in shallow iron pots (Dutch ovens) containing not more than 30 pounds of sulphur for each pot, and the pots should stand in vessels of water. The sulphur pots should be elevated from the bottom of the compartment to be disinfected, in order to obtain the maximum possible percentage of combustion of sulphur. The sulphur should be in a state of fine division, and ignition is best accomplished by alcohol; special care to be taken with this method to prevent damage to cargo of vessel by fire; or the sulphur may be burned in a special furnace, the sulphur dioxid being distributed by a power fan. This method is peculiarly applicable to cargo vessels.

156. Liquefied sulphur dioxid may be used for disinfection in place of sulphur dioxid generated as above, it being borne in mind that this process will require 2 pounds of the liquefied gas for each pound of sulphur as indicated in the above paragraphs.

157. Sulphur dioxid is especially applicable to the holds of vessels, or to freight cars and apartments that may be tightly closed and which do not contain objects injured by the gas. Sulphur dioxid bleaches fabrics or materials dyed with vegetable or anilin dyes. It destroys linen or cotton goods by rotting the fiber through the agency of the acids formed. It injures most metals. It is promptly destructive to all forms of animal life. This property renders it a valuable agent for the extermination of rats, insects, and other vermin.

FORMALDEHYD GAS.

158. Formaldehyd gas is effective if applied by one of the methods given below. Formaldehyd gas has the advantage as a disinfectant that it does not injure fabrics or most colors. It is not poisonous to the higher forms of animal life. It fails to kill vermin, such as rats, mice, roaches, bedbugs, etc. The method is not applicable to the holds of large vessels. Formaldehyd is applicable to the disinfection of rooms, clothing, and fabrics, but should not be depended upon for bedding, upholstered furniture, and the like, when deep penetration is required.[1]

159. Many formaldehyd solutions do not contain 40 per cent. of formaldehyd, and all are apt to deteriorate with time. It is therefore necessary to use a quantity in excess of the amount prescribed in these regulations, unless the solution has been recently analyzed.

160. The following methods of evolving the gas may be used:

(*a*) Autoclave under pressure, three to twelve hours' exposure.

(*b*) Lamp or generator, six to eighteen hours' exposure.

[1] It should be noted that formaldehyd disinfection is more efficient in warm, moist, or still weather than in cold, dry, or windy weather.

(*c*) Spraying, twelve to twenty-four hours' exposure.

(*d*) Formaldehyd and dry heat in partial vacuum, one hour's exposure.

161. The minimum number of hours' exposure as given above applies to empty rooms of tight construction containing smooth, hard surfaces; the maximum number of hours' exposure applying in all cases to textiles and other articles of a similar kind requiring more or less penetration.

162. Autoclave under pressure. This method has considerable penetrating power when applied as detailed below. Rooms or apartments need no special preparation beyond the ordinary closing of doors and windows. Pasting, caulking, or chinking of ordinary cracks and crevices is not necessary. The doors of lockers and closets and the drawers of bureaus should be opened. In this apparatus use formalin (40 per cent.), with the addition of a neutral salt, such as calcium chlorid (20 per cent.). The gas must be evolved under a pressure not less than 45 pounds. After the gas is separated from its watery solution the pressure may be allowed to fall and steam projected into the compartment to supply the necessary moisture. Use not less than 10 ounces of formalin per 1000 cubic feet, and keep the room closed for three to twelve hours after the completion of the process. For large rooms the gas must be introduced at several points as far apart as possible. It is applicable to the disinfection of clothing and fabrics suspended loosely in such a manner that every article is freely accessible to the gas from all directions.

163. Lamp or generator. This method requires an apparatus producing formaldehyd by a partial oxidation of wood alcohol, and in using it the room or apartment should be rendered tight as practicable. Oxidize 24 ounces of wood alcohol per 1000 cubic feet, and keep the room closed for six to eighteen hours, in accordance with the provisions of paragraph 165. This method leaves little or no odor. When applied to clothing and textiles, the articles should be suspended in a tight room and so disposed as to permit free access of the gas. (See also paragraph 166.) The wood alcohol should be of 95 per cent. strength, and should not contain more than 5 per cent. of acetone.

164. Spraying. The formalin (40 per cent.) should be sprayed on sheets suspended in the room in such a manner that the solution remains in small drops on the sheet. Spray not less than 10 ounces of formalin (40 per cent.) for each 1000 cubic feet. Used in this way a sheet will hold about 5 ounces without dripping or the drops running together. The room must be very tightly sealed in disinfecting with this process, and kept closed not less than twelve hours. The method is limited to rooms or apartments not exceeding 2000 cubic feet. The formalin may also be sprayed upon the walls, floors, and objects in the rooms.

This method is markedly interfered with by, and is not to be relied on at, low temperatures, say, below 72° F. At 43.5° F. very little formaldehyd is liberated, the formaldehyd being polymerized on the sheets.

165. Formaldehyd with dry heat in partial vacuum. This method has superior penetrating powers, and is specially applicable to clothing and baggage. The requirements of this method are (1) dry heat of 60° C. sustained for one hour; (2) a vacuum of 15 inches; (3) formaldehyd evolved from a mixture of formalin with a neutral salt, in an autoclave under pressure, using not less than 30 ounces of formalin (40 per cent.) for 1000 cubic feet; and (4) a total exposure, under these combined conditions, of one hour.

166. Chemical, as—

(1) Formalin permanganate method. When formalin is poured over crystals of permanganate of potash, a vigorous reaction takes place, and a large quantity of formaldehyd gas is liberated. Reaction is over in a short time, five minutes, and if a proper proportion of substances is used, the residue is almost dry. The proportion is 2 pints of formalin to 1 pound of permanganate of potash. One pint of formalin for 1000 cubic feet of space, should be used if the temperature is 60° F. or less, a less amount may be used for higher temperatures, but not less than 10 ounces per 1000 cubic feet. This method is extremely efficient on account of the rapidity with which the gas is liberated, but the danger of fire should be guarded against, as the formaldehyd gas, being in a comparatively dry state, is inflammable in the presence of a light, such as lighted matches, lamp, etc.

(2) Formalin-aluminum sulphate-lime method. Add 1 part sulphate of aluminum to 2 parts of hot water. One part of this solution is added to 2 parts of formalin (both by volume). One part of this second solution is poured on 2 parts of unslaked lime (quick lime), broken into small particles. The process of liberation of formaldehyd gas is completed in about twenty minutes. This method is not as efficient as the previous one, as less than half the amount of formaldehyd gas is yielded from the same amount of formalin.

Two pints of formalin per 1000 cubic feet of space should be used, if the temperature is 60° F. or less.

Fire should be guarded against, but this danger is decidedly less than in the permanganate process on account of the large amount of water vapor coming off with the gas.

167. The stated times of exposure to sulphur dioxid and formaldehyd are sufficient to destroy bacterial infection due to non-spore-bearing organisms, providing that the infection is present on the surface. If the room is of peculiar construction, so as to

impede the diffusion of the gas, or if the room is a dirty one, or if on account of any other condition rendering the germicidal action of the gas more difficult, the time of exposure should be proportionately increased, or supplanted by other methods.

CHEMICAL SOLUTIONS.

168. Bichlorid of mercury. Bichlorid of mercury is a disinfectant of undoubted potency and wide range of applicability. It cannot be depended upon to penetrate substances in the presence of albuminous matter. It should be used in solutions of 1 : 1000. The solubility of bichlorid of mercury may be increased by using sea-water for the solution, or by adding 2 parts per 1000 of sodium or ammonium chlorid to the water employed.

169. Carbolic acid. Carbolic acid in the strength of 5 per cent. (see paragraph 52) may be substituted for the bichlorid of mercury, and should be employed in the disinfection of the cabins and living apartments of ships to obviate injurious action on polished metals, bright work, etc.

170. Formalin. Formalin containing 40 per cent. of formaldehyd may be used in a 5 per cent. solution as a substitute for bichlorid of mercury or carbolic acid, and is useful for the disinfection of surfaces, dejecta, fabrics, and a great variety of objects, owing to its non-injurious character.

Application of Disinfectants in Quarantine Work.

171. Holds of iron vessels, empty, shall be disinfected by either:

(*a*) Sulphur dioxid degenerated by burning sulphur 5 pounds per 1000 cubic feet of air-space, or liberated from 10 pounds of liquid sulphur dioxid, sufficient moisture being present in both cases; time of exposure, twenty-four hours. (See paragraph 154.)

(*b*) Washing with a solution of bichlorid of mercury, 1 : 1000.

172. Holds of wooden vessels, empty, shall be disinfected by:

(*a*) Sulphur dioxid in the manner prescribed above, followed by—

(*b*) Washing with a solution of bichlorid of mercury.

173. Holds of cargo vessels, when cargo cannot be removed, shall be disinfected in so far as possible by sulphur dioxid not less than 4 per cent. per volume strength, and where possible this should be generated from a furnace to minimize danger of fire in cargo.

174. Living apartments, cabins, and forecastles of vessels shall be disinfected by one or more of the following methods:

(*a*) Sulphur dioxid, the destructive action of the gas on property being borne in mind.

(*b*) Formaldehyd gas.

(*c*) Washing with solution of bichlorid of mercury, 1 : 1000 or 5

per cent. solution of formalin, or 5 per cent. solution of carbolic acid, preference being given to carbolic acid for application to polished woods, bright metals, and other objects injured by metallic salts.

The forecastle, steerage, and other living apartments in bad sanitary condition must be disinfected by method (*a*), followed by method (*c*).

175. Mattresses, pillows, and heavy fabrics are to be disinfected by:

(*a*) Boiling.

(*b*) Flowing steam—*i. e.*, steam not under pressure.

(*c*) Steam under pressure.

(*d*) Steam in a special apparatus with vacuum attachment.

176. Clothing, fabrics, textiles, curtains, hangings, etc., may be treated by either of the above methods from (*a*) to (*d*) inclusive, as circumstances may demand, or by formaldehyd gas or sulphur dioxid where the article is of a character which will not be damaged by sulphur dioxid.

177. Articles injured by steam, such as leather, furs, skins, rubber, trunks, valises, hats and caps, bound books, silks, and fine woolens should not be disinfected by steam. Such articles should be disinfected by formaldehyd gas or by any of the agents allowed in these regulations which may be applicable thereto. Those which will be injured by wetting should be disinfected by a gaseous agent.

178. Clothing, textiles, and baggage, clean and in good condition, but suspected of infection, can be efficiently and least injuriously disinfected by formaldehyd gas, generated by one of the methods prescribed in paragraph 160—(*a*), (*b*), or (*d*).

179. Textiles which are soiled with the discharges of the sick or presumably are deeply infected, must be disinfected by:

(*a*) Boiling.

(*b*) Steam.

(*c*) Immersion in one of the germicidal solutions.

180. Cooking and eating utensils are always to be disinfected by immersion in boiling water or by steam.

Agents for the Destruction of Mosquitoes, Rats, and Other Vermin, and Their Application to Quarantine Work.

181. Sulphur dioxid—obtained as described in paragraphs 154 and 155—destroys all animal life.

182. In the case of vessels, when treated for yellow fever infection, the process shall be a simultaneous fumigation with sulphur dioxid, 2 per cent. volume gas, and two hours' exposure, in order to insure the destruction of mosquitoes.

183. In the case of vessels when treated for plague the process with sulphur dioxid shall be as follows:

Without cargo: The simultaneous fumigation with sulphur dioxid gas not less than 2 per cent. for six hours' exposure.

With cargo: Fumigation with sulphur dioxid gas, 4 per cent., six to twelve hours' exposure, according to stowing.

Infected vessels may require partial or complete discharge of cargo, and fractional fumigation for efficient deratization.

184. Pyrethrum. The fumes of burning pyrethrum may be used to destroy mosquitoes in places where there are articles liable to be injured by the use of sulphur.

Four pounds per 1000 cubic feet space for two hours' exposure with this amount all or practically all of the mosquitoes will be killed, but precautions should be taken to sweep up and destroy any that may have escaped.

Pyrethrum stains walls, paper, etc.

185. The oxids of carbon, as used at Hamburg, are efficient to destroy rats, but do not kill fleas or other insects. They are obtained by burning carbon, coke, or charcoal in special apparatus, and the gas as produced consists of about 5 per cent. carbon monoxid, 18 per cent. carbon dioxid, and 77 per cent. nitrogen.

Twenty kilos of carbon, coke, or charcoal are used for every 1000 meters of space. The gas is allowed to remain in the ship for two hours and from seven to eight hours are allowed for it to leave it. This is about equivalent to 1¼ pounds of carbon (coke) to 1000 cubic feet of air space. As this gas is very fatal to man and gives no warning of its presence, being odorless, a small amount of sulphur dioxid should be added to give warning of its presence. As it does not kill fleas, it cannot be depended on for complete work, where there is evidence of plague among rats on the vessel, as the infected fleas would infect the rats coming aboard after the deratization.

186. The articles named as disinfectants which can obviously destroy animal life can be used for that purpose when applicable, as steam for bedding, fabrics, etc. Formaldehyd is not applicable for this purpose.

187. Where both disinfection and destruction of vermin are required for mattresses, pillows, and fabrics, the use of steam meets both requirements, and is especially applicable.

188. Hydrocyanic acid gas is fatal to all forms of animal life and is not injurious to any material. It is best generated by mixing—

Cyanid of potash	4
Sulphuric acid	6
Water	9

The acid should first be diluted, which must be done in some vessel capable of withstanding the heat. The whole amount of the cyanid of potash must be put in the acid at once, and as the

evolution of the gas is very rapid, the operator must be prepared to leave immediately. Fulton advises that the cyanid be tied in a bag, to be lowered into the acid by a cord passing outside of the room.

About 10 ounces of cyanid of potash per 1000 cubic feet.

It is, of course, applicable when necessary to destroy mosquitoes or vermin (particularly in living quarters), but is too dangerous to be used except by those experienced in its use, and then under most rigid precautions. Though destructive to animal life, hydrocyanic acid gas is but of slight value as a germicide.

INTERSTATE QUARANTINE.

All interstate quarantine powers of the United States have also been conferred upon the Supervising Surgeon-General of the Marine-Hospital Service. The following is a transcript of the act of Congress conferring these powers and the interstate quarantine regulations:

[Act of March 27, 1890.]

An Act to prevent the introduction of contagious diseases from one State to another, and for the punishment of certain offences.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That whenever it shall be made to appear to the satisfaction of the President that cholera, yellow fever, small-pox, or plague exists in any State or territory, or in the District of Columbia, and that there is danger of the spread of such disease into other States, territories, or the District of Columbia, he is hereby authorized to cause the Secretary of the Treasury to promulgate such rules and regulations as in his judgment may be necessary to prevent the spread of such disease from one State or territory into another, or from any State or territory into the District of Columbia, or from the District of Columbia into any State or territory, and to employ such regulations to prevent the spread of such disease. The said rules and regulations shall be prepared by the Supervising Surgeon-General of the Marine-Hospital Service, under the direction of the Secretary of the Treasury. And any person who shall wilfully violate any rule or regulation so made and promulgated shall be deemed guilty of a misdemeanor, and upon conviction shall be punished by a fine of not more than five hundred dollars, or imprisonment for not more than two years, or both, in the discretion of the court.

SEC. 2. That any officer, or person acting as an officer, or agent of the United States at any quarantine station, or other person employed to aid in preventing the spread of such disease, who

shall wilfully violate any of the quarantine laws of the United States, or any of the rules and regulations made and promulgated by the Secretary of the Treasury, as provided for in Section 1 of this act, or any lawful order of his superior officer or officers, shall be deemed guilty of a misdemeanor, and upon conviction shall be punished by a fine of not more than three hundred dollars, or imprisonment for not more than one year, or both, in the discretion of the court.

SEC. 3. That when a common carrier, or officer, agent, or employé of any common carrier, shall wilfully violate any of the quarantine laws of the United States, or the rules and regulations made and promulgated as provided for in Section 1 of this act, such common carrier, officer, agent, or employé shall be deemed guilty of a misdemeanor, and shall, on conviction, be punished by a fine of not more than five hundred dollars, or imprisonment for not more than two years, or both, in the discretion of the court.

INTERSTATE QUARANTINE REGULATIONS.

ARTICLE I.

QUARANTINABLE DISEASES.

(1) For the purposes of these regulations the quarantinable diseases are cholera (cholerine), yellow fever, small-pox, typhus fever, leprosy, and plague.

ARTICLE II.

NOTIFICATION.

(1) State and municipal health officers should immediately notify the Supervising Surgeon-General of the U. S. Marine-Hospital Service by telegraph or by letter of the existence of any of the above-mentioned quarantinable diseases in their respective States or localities.

ARTICLE III.

GENERAL REGULATIONS.

(1) Persons suffering from a quarantinable disease shall be isolated until no longer capable of transmitting the disease to others. Persons exposed to the infection of a quarantinable disease shall be isolated, under observation, for such a period of time as may be necessary to demonstrate their freedom from the disease.

All articles pertaining to such persons, liable to convey infection, shall be disinfected as hereinafter provided.

(2) The apartments occupied by persons suffering from quarantinable disease, and adjoining apartments when deemed infected, together with articles therein, shall be disinfected upon the termination of the disease.

(3) Communication shall not be held with the above-named persons and apartments, except under the direction of a duly qualified officer.

(4) All cases of quarantinable disease, and all cases suspected of belonging to this class, shall be at once reported by the physician in attendance to the proper authorities.

(5) No common carrier shall accept for transportation any person suffering with a quarantinable disease, nor any infected article of clothing, bedding, or personal property.

The body of any person who has died of a quarantinable disease shall not be transported save in hermetically sealed coffins, and by the order of the State or local health officer.

(6) In the event of the prevalence of small-pox, all persons exposed to the infection, who are not protected by vaccination or a previous attack of the disease, shall be at once vaccinated or isolated for a period of fourteen days.

(7) During the prevalence of cholera all the dejecta of cholera patients shall be at once disinfected as hereinafter provided, to prevent possible contamination of the food- and water-supply.

Article IV.

YELLOW FEVER.

In addition to the foregoing regulations contained in Article III. the following special provisions are made with regard to the prevention of the introduction and spread of yellow fever:

(1) Localities infected with yellow fever, and localities contiguous thereto, should be depopulated as rapidly and as completely as possible, so far as the same can be safely done; persons from non-infected localities and who have not been exposed to infection being allowed to leave without detention. Those who have been exposed, or who come from infected localities, shall be required to undergo a period of detention and observation of ten days from the date of last exposure in a camp of probation or other designated place.

Clothing and other articles capable of conveying infection shall not be transported to non-infected localities without disinfection.

(2) Persons who have been exposed may be permitted to proceed without detention to localities incapable of becoming infected and whose authorities are willing to receive them and after arrangements have been perfected, to the satisfaction of the proper health officer, for their detention in said localities for a period of ten days.

(3) The suspects who are isolated under the provisions of paragraph 1, Article III., shall be kept free from all possibility of infection.

(4) So far as possible, the sick should be removed to a central location for treatment.

(5) Buildings in which yellow fever has occurred, and localities

believed to be infected with said disease, must be disinfected as thoroughly as possible.

(6) As soon as the disease becomes epidemic the railroad trains carrying persons allowed to depart from a city or place infected with yellow fever shall be under medical supervision.

(7) Common carriers from the infected districts, or believed to be carrying persons and effects capable of conveying infection, shall be subject to a sanitary inspection, and such persons and effects shall not be allowed to proceed, except as provided for by paragraph 2.

(8) At the close of an epidemic the houses where sickness has occurred, and the contents of the same, and houses and contents that are presumably infected, shall be disinfected as hereinafter prescribed.

Article V.

DISINFECTION.

FOR CHOLERA.

(1) The dejecta and vomited matters of cholera patients shall be received into vessels containing an acid solution of bichlorid of mercury (bichlorid of mercury, 1 part; hydrochloric acid, 2 parts; water, 1000 parts) or other efficient germicidal agent.

(2) All bedding, clothing, and wearing apparel soiled by the discharges of cholera patients shall be disinfected by one or more of the following methods:

(*a*) By complete immersion for thirty minutes in one of the above-named disinfecting solutions.

(*b*) By boiling for fifteen minutes; all articles to be completely submerged.

(*c*) By exposure to steam at a temperature of 100° to 102° C. for thirty minutes after such temperature is reached.

(3) Any woodwork or furniture contaminated by cholera discharges shall be disinfected by thorough washing with a germicidal solution, as provided in paragraph 1, Article III.

FOR YELLOW FEVER.

(4) Apartments infected by occupancy of patients sick with yellow fever shall be disinfected by one or more of the following methods:

(*a*) By thorough washing with one of the above-named germicidal solutions. If apprehension is felt as to the poisonous effects of the mercury, the surfaces may, after two hours, be washed with clear water.

(*b*) Thorough washing with a 5 per cent. solution of pure carbolic acid.

(*c*) By sulphur dioxid, twenty-four to forty-eight hours' exposure, the apartments to be rendered as air-tight as possible.

(5) Bedding, wearing apparel, carpets, hangings, and draperies infected by yellow fever shall be disinfected by one of the following methods:

(*a*) By exposure to steam at a temperature of 100° to 102° C. for thirty minutes after such temperature is reached.

(*b*) By boiling for fifteen minutes; all articles to be completely submerged.

(*c*) By thorough saturation in a solution of bichlorid of mercury 1 : 1000, the articles being allowed to dry before washing.

Articles injured by steam (rubber, leather, containers, etc.), to the disinfection of which steam is inapplicable, shall be disinfected by thoroughly wetting all surfaces with (*a*) a solution of bichlorid of mercury 1 : 800, or (*b*) a 5 per cent. solution of carbolic acid, the articles being allowed to dry in the open air prior to being washed with water, or (*c*) by exposure to sulphur fumigation in an apartment air-tight, or as nearly so as possible.

FOR SMALL-POX.

(6) Apartments infected by small-pox shall be disinfected by one or both of the following methods:

(*a*) Exposure to sulphur dioxid for twenty-four to forty-eight hours.

(*b*) Washing with a solution of bichlorid of mercury, 1 : 1000, or a 5 per cent. solution of pure carbolic acid.

(7) Clothing, bedding, and articles of furniture exposed to the infection of small-pox shall be disinfected by one or more of the following methods:

(*a*) Exposure to sulphur dioxid for twenty-four to forty-eight hours.

(*b*) Immersion in a solution of bichlorid of mercury, 1 : 1000, or 5 per cent. solution of pure carbolic acid.

(*c*) Exposure to steam at a temperature of 100° to 102° C. for thirty minutes after such temperature is reached.

(*d*) Boiling for fifteen minutes; the articles to be completely submerged.

FOR TYPHUS FEVER.

(8) Apartments infected by typhus fever shall be disinfected by one or both of the following methods:

(*a*) Exposure to sulphur dioxid for twenty-four to forty-eight hours.

(*b*) Washing with a solution of bichlorid of mercury, 1 : 1000, or a 5 per cent. solution of pure carbolic acid.

(9) Clothing, bedding, and articles of furniture exposed to the infection of typhus fever shall be disinfected by one or more of the following methods:

(*a*) Exposure to sulphur dioxid for twenty-four to forty-eight hours.

(*b*) Immersion in a solution of bichlorid of mercury, 1 : 1000, or a 5 per cent. solution of pure carbolic acid.

(*c*) Exposure to steam at a temperature of 100° to 102° C. for thirty minutes after such temperature is reached.

(*d*) Boiling for fifteen minutes; the articles to be completely submerged.

INTERSTATE QUARANTINE REGULATIONS TO PREVENT THE SPREAD OF PLAGUE IN THE UNITED STATES.

In accordance with the provisions of the act of March 27, 1890, the following regulations, additional to existing interstate quarantine regulations, are hereby promulgated to prevent the introduction of plague into any one State or territory or the District of Columbia, from another State or territory or the District of Columbia:

1. During the existence of plague at any point in the United States the Surgeon-General of the Marine-Hospital Service is authorized to forbid the sale or donation of transportation by common carrier to Asiatics or other races particularly liable to the disease.

2. No common carrier shall accept for transportation any person suffering with plague or any article infected therewith, nor shall common carriers accept for transportation any class of persons who may be designated by the Surgeon-General of the Marine-Hospital Service as being likely to convey the risk of plague contagion to other communities, and said common carriers shall be subject to inspection.

3. The body of any person who has died of plague shall not be transported except in an hermetically sealed coffin and by consent of the local health office, in addition to the local representatives of the Marine-Hospital Service. Wherever possible, such bodies should be cremated.

STATE QUARANTINE REGULATIONS.

Many of the seaboard States of the Union have quarantine boards and stations in addition to those of the national government. In 1893 the legislature of Pennsylvania passed a law establishing the State Quarantine Board for the Port of Philadelphia.

As early as 1708, "An act to prevent sickly vessels coming into this government" was passed by the colonial assembly, prohibiting every unhealthy or sickly ship from an unhealthy or sickly place from coming nearer than one mile to any of the towns or ports of the province or territories without clean bills of health. This

act remained in force until January 22, 1744. About the year 1742 a quarantine station was located at Fisher's Island, subsequently called Province, and State Island. In 1749 the trustees of Province Island were directed to build an hospital or pest-house for the reception of strangers imported into the province. During the period of the revolutionary war commerce had so dwindled that there was very little necessity for a quarantine station. The hospital, however, was used for the care of sick persons sent from army boats.

The invasion of yellow fever was instrumental in causing an order to be given for the repairment of the hospital upon State Island for the admission of patients and the appointment of a resident physician. A resident physician was appointed at the hospital, and vessels coming up the river were ordered to anchor for a visit.

In 1799 the quarantine station was located at Tinicum Island, and the removal took place in 1801, at which place it was maintained until 1895, when it was removed to Marcus Hook, its present location. The service at State station, because of the two national quarantine stations (Cape Henlopen and Reedy Island), is, for the present, one of observation or inspection only, there being no provision for detention or disinfection. If sickness of a communicable nature is discovered on a vessel, or if circumstances lead to the suspicion that the vessel herself is infected, she is simply remanded to the Federal quarantine station.

The right to quarantine resides with the individual States, though the Federal government has the right to control in such matters through its right to regulate interstate commerce. It should have control of the matter of inland quarantine to the extent of directing and superintending the measures adopted, in order to prevent the confusion arising from conflicting regulations of the authorities of adjacent localities. In order to secure more uniformity in the measures adopted, Congress has been petitioned time and again to pass a

law providing for the organization of a National Board of Health.

The regulations of the various State boards of health are directed toward the prevention of the introduction of infected individuals and materials from other States or countries and toward the control of infection within the borders of the State.

Notwithstanding the fact that the national government has taken over a number of the State quarantine stations along the seaboard, several of the States still maintain inspection and quarantine stations at ports of entry, namely: Maryland, Massachusetts, New York, and Texas.

The institution of quarantine by one State against a neighboring State is specifically provided for in the laws of California, Connecticut, Georgia, Indiana, Illinois, Kansas, Kentucky, Louisiana, Maine, Maryland, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Hampshire, New Jersey, New Mexico, North Carolina, Ohio, Oklahoma, Oregon, Pennsylvania, Tennessee, Virginia, West Virginia, and Wyoming.

In recent years these interstate quarantine laws have rarely been required to control any infectious disease, because, in most States, the local quarantine regulations have been sufficient to keep infectious diseases under control.

During the epidemic of poliomyelitis which prevailed during the summer of 1916 state quarantine laws were brought into use. The transference of children from one state to another was controlled by placing inspectors at all the important points of communication between some of the states and the states along their borders. All children passing the border were obliged to show certificates of health.

House Quarantine.—The diseases against which house quatantine is directed differ in different State laws, some requiring modified quarantine in some dis-

eases and in others simply a reporting of the diseases and placarding of the houses. Strict quarantine is maintained by all the States against small-pox, scarlet fever, and diphtheria. Many of the States include in this list Asiatic cholera, yellow fever, typhus fever, and bubonic plague.

With regard to many of the other communicable diseases, practices differ very much. The following diseases are reportable in most of the States: Measles, typhoid fever, epidemic cerebrospinal meningitis, tuberculosis, and leprosy. In the following diseases placarding is usually required, or a modified quarantine is instituted, namely: Whooping-cough, mumps, chicken-pox, and German measles. In addition, the following diseases are reportable in some of the States: Epidemic dysentery, dengue, anthrax, glanders, pneumonia, tetanus and relapsing fever, syphilis, and puerperal fever. In the regulations of many of the States membranous croup is classified under diphtheria, and the regulations that pertain to diphtheria are applied to cases of so-called membranous croup. Likewise, in Pennsylvania and California, Cuban or Manila itch are reportable. In addition to this, actinomycosis is reportable in Pennsylvania, hydrophobia in Louisiana, ophthalmia neonatorum in Nebraska and New York, uncinariasis in California, and erysipelas in Pennsylvania. Massachusetts has made the following diseases reportable: actinomycosis, anterior poliomyelitis, anthrax, cerebrospinal meningitis, chicken-pox, diphtheria, dog-bite, dysentery, German measles, glanders, gonorrhea, hook-worm disease, leprosy, lobar pneumonia, malaria, measles, mumps, ophthalmia neonatorum, scarlet fever, septic sore throat, smallpox, syphilis, tetanus, trachoma, trichinosis, tuberculosis, typhoid fever, and whooping-cough. All of the States require the reporting of anterior poliomyelitis.

House quarantine differs considerably in different States and cities. The statutes of New York define as quarantinable "yellow fever, measles, cholera, typhus fever,

small-pox, scarlet fever, diphtheria, relapsing fever, and any disease of a contagious, infectious, or pestilential character, which shall be considered by the health officer dangerous to the public health."

In New York City every case of contagious disease reported to the health department is regularly inspected by the medical inspector assigned to the district in which it occurs. When consent can be obtained, the cases are removed to the department hospitals. In the tenement-house districts an effort is always made to induce patients suffering from such diseases to enter the hospitals, and, if the conditions are such as to require it, removal to the hospitals is enforced. After completion of the illness or transfer of the patient, thorough disinfection is made of the house or apartment, and all infected materials are removed to the disinfecting station for destruction or disinfection by steam, when they are returned to the owner. No charge is made for these services, and disinfection is compulsory in every case. The practice in Philadelphia and other large cities is quite similar to that in New York.

The infectious diseases in which notification is compulsory in Philadelphia are : Cholera, small-pox, diphtheria, diphtheritic croup, membranous croup, scarlet fever, measles, typhoid fever, typhus fever, epidemic cerebrospinal fever, relapsing fever, and leprosy. Knowledge of cases of diphtheria reaches the department of health through the forwarding of a culture to the bacteriologic laboratory for examination, as well as by notification by the physician. If, on examination, the culture is found to contain diphtheria bacilli, the case is at once reported to the medical inspector, at the same time that a report is forwarded to the attending physician. In this manner doubtful cases are diagnosed early, and no hardships are entailed upon the suspect or the family, while the community is protected by prompt isolation of all such cases. The contagious character of tuberculosis in all its forms is becoming more and more generally recognized. Nevertheless there is strenuous opposition from many sources

to the notification of cases of tuberculosis. In New York and Philadelphia such notification is now required, not with the idea of quarantining the cases, but in order to keep informed as to their location, and to make it possible to direct approved prophylactic measures against the spread of the disease from the sick to the well. No general disinfection of the premises occupied by cases of tuberculosis in the tenement district is attempted. On the other hand, all such premises are thoroughly renovated after the removal or death of the tubercular patient. In this manner the danger from infection through infective dust is greatly lessened. The work of the department is hampered, however, because of the absence of sufficient hospital accommodations for consumptive poor. Most beneficial effects have, however, already resulted from the various measures instituted for the prevention of tuberculosis, as shown in the very material decline in the number of deaths occurring from it.

The investigations of Anders and of Flick, of Philadelphia, and those of Biggs, of New York, show that tuberculosis is not uniformly diffused through a community, not even in those localities where it occurs most frequently, but is confined largely within narrow boundaries, as in certain streets and within the walls of certain houses. These investigations have shown that when a house is once infected, repeated cases are developed in it from the new tenants occupying such a house. These infected houses are most frequently found in the narrower streets, in courts, and in alleys. Though there is some danger of infection from the inhalation of dust in the open air in crowded parts of the city, it seems probable that a more prolonged exposure to a concentrated atmosphere of infection, as found in these infected houses, is the most frequent mode of contracting the disease. The dust in street-cars and various public places is often infected, and may lead to contraction of the disease. The prohibition of spitting on the floor of cars, ferry-boats, and other public conveyances should, therefore, be strictly enforced as a wise sanitary measure.

CHAPTER XX.

VITAL STATISTICS.

VITAL statistics includes the records of all circumstances affecting the production and duration of human life, and corresponds to the term "démographie" employed by French writers. The registration of vital statistics includes the obtaining of records of births, deaths, marriages, and disease. The comparison of these records with each other, and with the statistics of the living population, comprises vital statistics proper.

The systems of registration employed by different States and cities differ as to details. They include a periodical report of the births, with date and place of birth, sex, color, and nationality of the child, and the names, residence, birthplace, age, and occupation of the parents. These reports are usually made monthly by the physician to the health bureau of the city. Deaths are reported through the physician and undertaker to the health authorities, who issue a burial permit. The information furnished on the death certificate includes the age, sex, color, nationality, and conjugal condition of the deceased, as well as the immediate and remote causes of death. In the United States the physician acts in a judicial capacity in reporting a death. Upon this fact is based the right of legislation regulating the education and qualification of medical men and the laws regulating the practice of medicine. He is a State officer in relation to his knowledge of the cause of death.

The cases of infectious diseases are reported at once by the physician when the diagnosis has established the nature of the disease. Up to the present time only a few States have had an accurate system of registration. With the beginning of the twentieth century a number

of States and cities, as well as a large number of other countries, adopted a uniform system of classification of the causes of death, known as the Bertillon system. This system has been adopted generally after repeated conferences extending over a number of years. Dr. Bertillon presented his system of classification to the International Statistical Institute at Chicago in 1893. It has since received the endorsement of the American Public Health Association, the International Conference of State and Provincial Boards of Health of North America, and received its first International Decennial Revision at Paris in 1900. By the use of this uniform system of classification the vital statistics of different countries will be readily comparable. It is safe to presume that the general adoption of such a uniform system of classification, with decennial revisions of the same by those using it, will lead to more efficient registration methods wherever the system is employed. Full information as to the details of the Bertillon system of classification may be found in the publications of the American Public Health Association, of the Michigan Division of Vital Statistics, and the United States Public Health Service. Requiring a permit for burial is the only reliable means of obtaining the desired information. This is necessary to secure a proper inheritance of property. It also aids in detecting crime.

By means of an accurate system of registration a community is able to keep informed as to the condition of the public health, the efficiency of quarantine measures, the purity of the water-supply, and the death-rate from all diseases. The value of estimates made from vital statistics as reported to the health authorities is dependent upon a knowledge of the living population. In most countries this is determined decennially by means of a national census. Some cities have an additional census taken midway between the decennial censuses. In the absence of such special censuses the calculations are based on the results of the decennial censuses. The

Registrar-General of Scotland employs the following method for calculating the population for the inter-census years: He assumes that the rate of increase as ascertained from the two enumerations immediately preceding continues the same during the course of the next ten years. The sanitary department of Glasgow ascertains the number of houses inhabited by the census population, the average population per house, and then in each succeeding inter-census year applies this average as a multiplier to the inhabited houses for the year, as entered upon the rolls of the assessor. Neither of these methods gives accurate results. Since population increases in geometric proportion, the arithmetical mean may be taken between two censuses. The result will generally be less than normal, but will not vary more than 1 per 1000 in the death-rate as calculated from these data as compared with the results obtained from actual enumerations.

The Census as a Basis for Calculation.—It is essential, therefore, that an accurate census of the population be taken at stated intervals to form the basis of calculation of the results obtained from registrations of births, deaths, marriages, and disease. The density of population, or the number of persons occupying a definite area, is also of value, and this is obtained by dividing the population by the area in square meters, square miles, or in acres.

Standards of Age-distribution.—In order to make it possible to secure fair comparisons of the death-rates of different places, a uniform standard should be adopted to which all populations may be referred, or with which they may be compared. The committee on nomenclature of the American Public Health Association, in its report for 1895, states that, other things being equal, a city in which the persons living under one year of age, and those who are more than fifty years of age, constitute together more than 15 per cent. of the population, will have a higher death-rate than another city under similar conditions in which the persons of these ages constitute

less than 10 per cent. of the population, since the death-rate at these age-periods is invariably much higher than that of the remaining population, constituted as it is of children who have passed the first and most critical year of infancy, together with the vigorous population of early adult life. For example, in the comparatively new populations of such States or territories as Arizona, Nevada, Idaho, and the older state of Iowa, the ratios of persons of the two age-groups, under one year and all over fifty, were as follows, by the census of 1880:

PER CENT. OF PERSONS UNDER ONE AND OVER FIFTY YEARS TO THE TOTAL POPULATION.

Arizona	8.90 per cent.
Idaho	12.64 "
Nevada	10.52 "
Iowa	13.99 "

On the other hand, the per cent. of persons living at these age-periods in the two older States of Delaware and Vermont was as follows:

Delaware	15.92 per cent.
Vermont	21.85 "

Now, since the death-rate of children under one year is usually from eight to ten times as great as that of the total population, and that of persons over fifty is usually not far from twice as large, it follows that, other things being equal, we may expect to find a general death-rate in these older States correspondingly greater than that of the newer communities."

The committee advocated the adoption of the method recommended by Körösi, of Budapesth, as being the most simple, the least cumbrous, and the one that is sufficiently accurate for the purposes for which it is designed. Körösi's method comprises a division into four age-groups, as follows: Under one year, one to twenty years, twenty to fifty years, all over fifty years.

Körösi also recommends that the age-distribution of

only one country, for example, that of Sweden, be employed as standard. The distribution of Sweden by the census of 1880 was as follows:

Age-period.	Per cent.
Under one year	2.65
One to twenty years	39.81
Twenty to fifty years	38.62
All over fifty	18.92

The method of application is as follows, as applied to Massachusetts:

Age-groups.	Standard distribution, Sweden, 1880.	Death-rate, Massachusetts, 1880.	Mortality index.
0–1	2.65	19.13 per cent.	5.07
1–20	39.81	1.28 " "	5.09
20–50	38.62	1.03 " "	3.98
all over 50	18.92	3.90 " "	7.38
	100.00		21.52

In Dr. Ogle's standard, which is in use in England, the population is divided into twelve age-groups. These groups, and the annual rate of mortality in England per 1000 persons living, are shown in the following table from the Registrar-General's report for 1880:

	All ages.	0 to 5	5 to 10	10 to 15	15 to 20	20 to 25	25 to 35	35 to 45	45 to 55	55 to 65	65 to 75	75 to 85	85 and upward.
England, average annual rate in twenty-five yrs. 1848–72.	22.4	67.9	8.3	4.8	6.7	8.8	9.9	12.7	17.0	30.1	62.0	139.6	294.2
England, 1880 . . .	20.5	64.4	6.3	3.3	4.8	6.1	7.7	11.5	16.0	30.4	61.2	131.3	257.9

The rate at each age-group is corrected to the proportion of the population at that age. The division into twelve age-groups, instead of four, increases the labor of computation threefold.

Calculation of the Birth-rate and Death-rate.—The birth-rate and the death-rate are both calculated at

an annual rate per 1000 of population. The births may be divided into several groups according to sex, race, or as regards legitimate and illegitimate births. Death-rates are of special value when calculated for different occupations, different diseases, and different age-groups. This information is of value because it indicates the occupations most injurious to health, and also the ages at which most deaths occur. Death-rates from the various exanthemata are also of special importance, because the course of an epidemic can be traced by this means; its relative severity can be compared with preceding epidemics; and especially the value of compulsory vaccination can be ascertained from the statistics of small-pox. The following formula is readily remembered, and will facilitate the calculation of death-rates: $M = \frac{1000\,D}{P}$ expressed in thousands, where $M =$ the mortality, $D =$ the number of deaths, and $P =$ the population.

Example.—In a population of 2000 there are 30 deaths, hence the death-rate is $\frac{1000 \times 30}{2000} = 15$ per 1000 of population. The mortality from a particular disease is expressed as so many per 100,000 of population, and the fatality of a disease is expressed in per cent. of the number of cases. The death-rate of a place is also influenced by other than the sanitary conditions of a place, such as the prevailing diseases of the locality, the nature of the occupations, the relative ages of the population, etc.

Rate of Infant Mortality.—The rate of infant mortality is measured by the proportion of deaths of infants under one year of age, to the number of births registered, and is expressed as so many per 1000 births. Stillbirths are excluded. The infant-mortality is considered to be one of the best tests of the sanitary condition of a locality, though this cannot apply to newly settled localities, where the infant population is necessarily quite small.

Death-rate of Persons Engaged in Various Occu-

pations.—The influence of occupation can be definitely determined only by studies of the death-rate of persons following those occupations, and this is done by determining the ratio of deaths at each age to those living during a certain time and engaged in the same occupation.

Mortality in Relation to Seasons.—The influence of the weather in favoring the production of certain diseases is shown in the death-rate from those diseases at certain seasons of the year; thus in winter there are a greater prevalence and a higher death-rate from diseases of the respiratory system, while in summer there are a greater prevalence and a higher death-rate from diseases of the gastro-intestinal tract. As a rule, the mortality is highest during the winter months, though where there is a large infant population the death-rate is frequently highest in summer because of the prevalence of infantile diarrhea.

Mean Age at Death.—The mean age at death of a population is the sum of the ages divided by the number of deaths. Due corrections must be made for age and sex distribution if these are not in accord with those of the general population. A large infant population will reduce the mean age at death though the health of the adult population is extremely good. De Chaumont gives the following formula for the approximate calculation of the mean duration of life: $\left(\frac{2}{3} \times \frac{1}{D}\right) + \left(\frac{1}{3} \times \frac{1}{B}\right) = x$, where B = the birth-rate, D = the death-rate pe1 unit of population (*i. e.*, 35 per 1000 = 0.035 per unit).

Example.—In England between 1871 and 1880 B = 35.35 per 1000 = 0.03535 per unit of population. D, for the same period, = 21.4 per 1000 = 0.0214 per unit of population, then $x = \left(\frac{2}{3} \times \frac{1}{0.0214}\right) + \left(\frac{1}{3} \times \frac{1}{0.03535}\right)$ = 40.58 years = the expectation of life at birth.

Mean Duration of Life.—The mean duration of life is the expectation of life at birth, and at any other age it

is expectation of life at that age, as taken from life tables, added to the age.

Probable Duration of Life.—The probable duration of life is the age at which a given number of children born at the same time will be reduced to half the number.

Expectation of Life.—The expectation of life is the average length of time a person of any age may be expected to live. This is computed from life tables. The following life table gives the results of computations from the mortality returns in England and America, and the results of the experiences of life insurance companies:

	Dr. Ogle's life table. England, 1871–80.		Humphrey's approximate English life tables.		Thirty American life insurance companies.		Massachusetts five years (1878–82).		Jews, United States, five years (1885–89).	
Age.	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.	Males.	Females.
0 yr.	41.35	44.62	41.92	45.25			41.74	43.50	63.51	59.63
1 "	48.05	50.14	48.64	50.75			49.84	50.24	68.33	63.57
2 yrs.	50.14	52.22	50.73	52.81			52.17	52.35	69.58	64.24
3 "	50.86	52.99	51.45	53.57			52.76	52.89	69.78	64.07
4 "	51.01	53.20	51.61	53.77			52.93	53.00	69.72	63.73
5 "	50.87	53.08	51.47	53.65			52.78	52.88	69.36	63.20
10 "	47.60	49.76	48.16	50.32	49.99	48.05	49.92	50.04	65.99	59.84
15 "			43.94	46.15	46.57	44.19	45.86	46.08	61.75	55.39
20 "	39.40	41.66	39.86	42.10	43.07	40.82	42.17	42.78	57.44	50.93
25 "			36.05	38.36	39.49	37.80	39.04	39.78	53.24	46.65
30 "	32.10	34.41	32.47	34.75	35.85	34.89	35.68	36.70	49.22	42.62
35 "			28.88	31.12	32.17	31.78	32.32	33.63	44.74	38.47
40 "	25.30	27.46	25.59	27.68	28.48	28.48	28.86	30.29	40.30	34.31
45 "			22.34	24.21	24.82	25.02	25.41	26.95	35.83	30.43
50 "	18.93	20.68	19.14	20.80	21.24	21.33	22.02	23.50	31.10	26.30
55 "			16.09	17.37	17.80	17.73	18.63	20.05	26.74	22.30
60 "	13.14	14.24	13.31	14.32	14.56	14.37	15.60	16.91	25.52	18.45
65 "			10.79	11.55	11.60	11.31	12.57	13.77	18.93	15.23
70 "	8.27	8.95	8.44	9.08	8.17	8.12	10.32	11.30	15.25	12.82
75 "			6.52	7.04	6.72	6.34	8.08	8.83	12.61	11.07
80 "	4.79	5.20	4.96	5.38	4.87	4.49	6.86	7.37	10.35	9.07
85 "			3.78	4.15	3.40	3.08	5.63	5.91	7.50	7.50
90 "	2.84	2.90	2.88	3.16	2.17	2.05				
95 "	2.17	2.17	2.20	2.40	1.34	1.34				
100 "	1.68	1.76	1.72	1.84						

In order to construct such a table, we must know the number of persons living, their ages, the number of deaths, and the ages at death, and changes in population caused by unusual birth-rate, by emigration, immigration, and other causes.

The expectation of life of females is greater than that of males according to the results obtained in England and in Massachusetts. The reverse is the case with the Jews of the United States. In the experience of the thirty life insurance companies of America the expectation of life of males is greater than that of females. This most interesting result obtained from the selected lives of the insured is difficult to explain. The relatively greater number of males insured may explain this difference in the result.

The results obtained in England and Massachusetts indicate that the female mortality is lower than the male mortality, and it is evident, therefore, that the dangers connected with childbearing do not prevent the general female mortality at childbearing ages from being lower than that of males.

The causes of the higher mortality among males are largely connected with the greater hardships and dangers connected with their occupations. In spite of the dangers of childbirth, married women have a much lower mortality than spinsters or widows. Widows of twenty to twenty-five years of age have a higher mortality than bachelors and married men of the same age.

The expectation of life after the first year increases up to the fourth year, and remains higher than at the first year up to about the seventeenth year. Willich gives the following formula for the approximate calculation of the expectation of life at any age: Expectation of life $= \frac{2}{3}(80 - a) = x$, where $a =$ the present age, and $x =$ the expectation of life. Thus at forty years, $\frac{2}{3} \times (80 - 40) = 26.66$ years.

Relation of Density of Population to the Death-rate.—The relation of the density of the population to the death-rate is most important. Dr. Farr found that the mortality increases with the density of the population, but not in direct proportion to the density, but as its sixth root. Thus if D and $D' =$ density of the population in two places, and M and M' the mortality, then

$\frac{M'}{M} = \sqrt{\frac{D'}{D}}$. The death-rate in each locality is, however, influenced by other factors than the mere fact of the existence of a certain number of persons in a specified area. The most important factors which influence the death-rate under all conditions are the proportion which the infant population bears to the whole, or, in other words, the average age of the population, the nature of the occupation of the people, and, above all, the general sanitary conditions of the surroundings.

Necessity of System of Notification.—Vital statistics cannot be obtained without some system of notification. Various objections have been raised against the notification of infectious diseases. The objection is frequently made that the friends of the patient wish to keep the matter secret, and that notification is a betrayal of confidence. There is usually delay in calling a physician, and this gives opportunity for the spread of the disease. The physician must be held responsible for reporting infectious diseases, otherwise the certainty of prompt notification is limited. The physician should be compensated for this extra work, though this is rarely done, and physicians should feel it a privilege to make the notifications, because it is the right of only those who are authorized to practise in a locality. It is, therefore, one mode of protecting the registered physicians against the invasion of those who are not qualified.

The notification of infectious diseases frequently causes great discomfort and pecuniary loss to those who are isolated in the infected area. It interferes with the liberty and comfort of a large number of people, though this discomfort is insignificant to the general discomfort and loss entailed by general epidemics.

Dr. Biddle, in a paper read before the Seventh International Congress of Hygiene, on "Should Compulsory Notification be made General?" gives the mean death-rates per 1000 living in twenty towns of England:

	1871–75.	1876–80.	1881–85.	1886–90.
All causes	24.81	23.26	21.84	21.19
Total zymotic	4.79	3.84	3.27	2.91
Notifiable zymotic	2.17	1.47	1.13	0.78

Notification has been in force since the adoption of the Public Health Act of 1875. While there was a decline in the death-rate from all causes from 1871–75 to 1886–90 of only 14.5 per cent., there was a decline of 39.2 per cent. in the death-rate from the total zymotic diseases, and a decline of 64 per cent. in the death-rate from the notifiable diseases during the same period, showing the great value of notification in infectious diseases.

A Sanitary Index.—As the general or crude death-rate, including deaths from all causes of disease, from old age as well as from all forms of violence, does not indicate the efficiency of public health administration, to a certain extent this deficiency is remedied by the presentation of statistics of the most prominent transmissible diseases, as typhoid fever, tuberculosis, and diphtheria, but the results are not as satisfactory as may be desired. The Pennsylvania Department of Health[1] groups together the acute communicable diseases of the epidemic type and tuberculosis (being the titles numbered 1 to 15 in the Abridged International Classification of the Causes of Death, excluding influenza), and including the deaths of infants under one year of age that are not included in the list of diseases specified. This group of diseases absorbs the maximum of effort and resources by boards of health, and the sum total of deaths from these causes may be regarded as a fair index of the efficiency of public agencies in conserving life and health.

Almost the entire reduction that has taken place in the general death-rate has been due to the reduction in the deaths from those diseases that are the objects of sanitary attack. By the separation of the causes of death

[1] *Report of the Commissioner*, 1915, p. 475.

into two groups, the one the acute infectious diseases specified, and the other the residual deaths, a comparison of the two groups will show the efficiency of public health agencies.

The ratio of the deaths included in the first group to each 1000 of population is termed the "sanitary index rate," and the deaths from all other causes to each 1000 of population is termed the "residual death-rate." The proportionate number of deaths involved in the construction of the sanitary index in 1906 was 40.5 per cent. of the total of 114,406 deaths from all causes. In 1915 it was 32.5 per cent. of the total of 115,284 deaths.

A high sanitary index as compared with the residual death-rate indicates deficient public health activities. An unfavorable age distribution through any cause will influence the sanitary index, as, for instance, the retirement of aged people from the farms to the smaller towns would give a relatively high residual death-rate for those towns.

APPENDIX.

Rules for interchange of different expressions of results of analysis:

To convert parts per 100,000 into grains per gallon (= parts per 70,000), multiply by 0.7.

To convert grains per gallon into parts per 100,000, multiply by 1.425.

To convert parts per million, or milligrams per liter, into grains per gallon, multiply by 0.07.

To convert grains per gallon into parts per million, or milligrams per liter, multiply by 0.142.

To convert nitrogen as nitrates into nitric anhydrid, multiply by 3.857.

To convert nitric anhydrid into nitrogen as nitrates, multiply by 0.2592.

To convert nitrogen as nitrites into nitrous anhydrid, multiply by 2.714.

To convert nitrous anhydrid into nitrogen as nitrites, multiply by 0.368.

To convert free or albuminoid ammonia into parts of nitrogen as ammonia, multiply by 0.824.

To convert nitrogen as ammonia into free or albuminoid ammonia, multiply by 1.214.

Rules for the conversion oj degrees of one thermometer scale into those of another:

Centigrade into Fahrenheit, multiply by 9, divide by 5, and add 32.

Fahrenheit into centigrade, deduct 32, multiply by 5, and divide by 9.

Fahrenheit into Réaumur, deduct 32, multiply by 4, and divide by 9.

Réaumur into Fahrenheit, multiply by 9, divide by 4, and add 32.

Centigrade into Réaumur, divide by 5 and multiply by 4.

Réaumur into centigrade, divide by 4 and multiply by 5.

Rules for conversion of kilogram-meters into foot-pounds and foot-tons, and vice versa:

To convert kilogram-meters into foot-pounds, multiply by 7.233.

To convert foot-pounds into kilogram-meters, multiply by 0.1382.

To convert kilogram-meters into foot-tons, multiply by 0.003229.

To convert foot-tons into kilogram-meters, multiply by 309.7.

Values of terms employed in connection with fuel-value of food:

1 calorie = the amount of heat required to warm 1 gram of water 1 degree centigrade = small calorie.

1 kilogram-calorie = the amount of heat required to warm 1 kilogram of water 1 degree centigrade = large calorie.

The mechanical equivalent of 1 calorie = 3100 foot-pounds.

Comparison of Metric and English Weights and Measures:

LENGTH.

1 meter	= 39.37	inches	= 3.28 feet.	
1 decimeter	= 3.94	"	= 4 inches, nearly.	
1 centimeter	= 0.394	inch	= $\frac{4}{10}$ inch.	
1 millimeter	= 0.0394	"	= $\frac{1}{25}$ " nearly.	
1 kilometer	= 1000	meters	= 1094 yards = $\frac{5}{8}$ mile, nearly.	
1 mile	= 1609	"	or 1.609 kilometers.	
1 yard	= 0.9144 meter.			
1 foot	= 0.3048	"	= 3.048 decimeters.	
1 inch	= 25.4 millimeters.			

CAPACITY.

1 liter = 1000 cubic centimeters = 61 cubic inches = 35.3 ounces = 2.182 pints = 0.264 gallon.
1 cubic centimeter = 0.061 cubic inch.
1,000,000 cubic centimeters = 1000 liters = 1 cubic meter = 35.3 cubic feet.
1 cubic meter = 265.78 gallons.
1 cubic inch = 16.4 cubic centimeters.
1 fluidounce = 28.3 cubic centimeters = 1.806 cubic inches.
1 cubic foot = 7.48 gallons = 1000 fluidounces = 28.32 liters.
1 cubic yard = 0.7645 cubic meter.
1 gallon = 3785.4 cubic centimeters = 3.7854 liters.
1,000,000 gallons = 3785.4 cubic meters.

WEIGHT.

1 cubic centimeter of water at 4° C. (39.2° F.) weighs 1 gram.

1 gram	= 15.432 grains	= 0.035 ounce.	
1 decigram	= 1.5432 "	= $1\frac{1}{2}$ grains, nearly.	
1 centigram	= 0.15432 grain	= $\frac{2}{13}$ grain	"
1 milligram	= 0.015 "	= $\frac{1}{65}$ "	"

1 kilogram = 1000 grams = 15,432 grains = 2.2046 lb. *avoir.* = 35.3 ounces.
1 grain = 65 milligrams, nearly.
1 ounce = 28.35 grams.
1 lb. *avoir.* = 453.6 " = 0.4536 kilogram.
1 ton *avoir.* (2240 lbs.) = 1016 kilograms.

AREA.

1 sq. meter	= 10.76 sq. feet	= 1550 sq. inches.	
1 sq. centimeter	= 0.155 sq. inch	= $\frac{2}{13}$ sq. inch, nearly.	
1 sq. millimeter	= 0.00155 "	= $\frac{1}{650}$ "	"

100 sq. meters = 1 are = 119.7 sq. yards = 3.954 sq. rods.
100 ares (hektar) = 11,967 sq. yards = 2.47 acres.
1 sq. kilometer = 1,000,000 sq. meters = 247 acres = 0.386 sq. mile.
1 sq. inch = 6.452 sq. centimeters = 645 sq. millimeters.
1 sq. foot = 0.0929 sq. meter = 9.29 sq. decimeters.
1 sq. yard = 0.8361 "
1 acre = 40.5 are, nearly = 0.405 hektar.

INDEX.

NAME	DATE DUE
ac Reed	MAY 1 '23
Dr. Langley Porter (R.K.P.)	AUG 8 '23
[illegible]	JAN 17 '24
Dr. Dickson	
	APR 17 '24
G.G. Thompson	JUL 16 '24
L. Shomu	SEP 27 '24
Dickson	APR 9 '25
Ernst Wolff	JAN 26 '26
J.H. Mannsfeldt	MAR 17 1926
V. Gerthe	JUN 29 1926